ORTHOPEDICS

for the

GENERAL PRACTITIONER

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for the
General Practitioner

by

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Dedicated To

THE HARD-WORKING GENERAL PRACTITIONER

May this book guide him in his orthopedic problems, lighten his burden, and make his professional life happier through a fuller understanding of this special branch of Medicine

Preface

Though the layman sometimes jokes about the doctor who "specializes in disturbances of the great toe," patients generally believe that all doctors know all things about all fields of medicine. While the specialist has a protection against the misconception that he is thoroughly experienced in every aspect of disease and its treatment, the family doctor, general practitioner, or personal physician finds that the public expects far more of him than it does of the specialist. He is expected to have a consummate knowledge of how to deliver babies, diagnose a hacking cough, set a fracture, and be all things to all men. The practitioner has borne this burden without complaint, but he needs help, we feel, especially in the field of Orthopedic Surgery. It is in order to lighten his load and to guide him that we have written this book.

The physician, in arriving at a diagnosis, has two very powerful tools: the complaint of the patient and the anatomic location about which the complaint is made. This book is so organized that the doctor can refer to that chapter dealing with the anatomic location pointed out by the patient (for example, the knee) and there find a list of usual complaints pertaining to such a location, with the likely diagnoses noted opposite the complaint; also will be found page references to the description of these conditions, ways and means of establishing diagnosis, and treatment. Those areas which might contain special difficulties or hidden dangers have also been indicated. By using this book, a doctor should be able to arrive at a diagnosis and outline his treatment with a minimum loss of time. If he is unable to satisfy himself that his diagnosis is correct, he will be well advised to seek a consultant's opinion forthwith.

The book should aid not only general practitioners, but also pediatricians. Since orthopedic disturbances in children have certain aspects which are quite different from the principles obtaining in the adult, a chapter is devoted to the conditions in childhood. A list of complaints according to anatomic region, together with the most likely diagnoses, is also included in this chapter.

Available books do not readily yield information pertinent to the family doctor's problems in the field of orthopedics. Textbooks leave out *many practical* answers, although most describe a given condition quite adequately. To use a text for diagnosis, however, means reading the entire book—something a physician

hardly can do when faced with an immediate problem. While many excellent books are available in the field of therapy, they are written for orthopedic surgeons, general surgeons, and residents in training and thus do not meet the needs of the general practitioner.

It is our sincere hope and honest conviction that this book will be primarily helpful to the family doctor in treating the orthopedic problems encountered and secondarily helpful to the orthopedic surgeon who may take over referral at the proper time.

No one who has ever written a book can fail to realize the importance of the contributions of time, skill, and effort of the people associated with him in the venture.

We particularly wish to mention Dr. D. Alexander Severino, Professor of Art at Ohio University, for many of the line drawings; Mr. Herbert Verry, O.T.R., Coordinator of the Cerebral Palsy Training Center of Fall River, for a number of excellent photographs; Dr. Larson's staff, for many of the illustrations; Miss Ethel I. Vieira, R.N., for her able assistance in reading, criticizing, and typing the manuscript; and Mrs. Judith Medieros and Mrs. Leone Hobbs, for typing the difficult scientific material.

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Chapter One

Diseases or Affections in Childhood

Orthopedic disturbances in childhood represent a very special segment in the field of orthopedic surgery. Diagnosis is simplified when consideration is given to the age of the child as well as to the anatomic location of the complaint. In order to direct attention to the affections most common at various age levels, a discussion is included of the numerous conditions found in childhood considered from the standpoint of age at which the complaints are commonly made.

AFFECTIONS AT VARIOUS AGE LEVELS

Diagnoses Common At Birth

The physician called to deal with an orthopedic difficulty in the newborn infant should keep in mind five general conditions, most of which are in the nature of congenital deformities. First, the child may have a congenital clubfoot (talipes equinovarus). One or both feet may be held tightly in the deformity of plantar flexion at the ankle, and inversion of the foot together with adduction of the forefoot may be present. The diagnosis is easily made by inspection and palpation. Second, the condition may concern the manner in which the newborn infant holds his head and neck. It will seem that the head in general is inclined to one side, the occiput pointing toward one shoulder and the chin toward the opposite shoulder. Examination will reveal a tight sternocleidomastoid muscle, with, frequently, a palpable lump in the midportion of the contracted muscle. Congenital torticollis is of course the diagosis of this condition. Third, a condition often encountered in the newborn infant is that the baby does not move one arm away from the side of his body or that he holds the arm to his side and keeps the hand clenched. Examination of such a child reveals that no attempt to induce abduction at the shoulder is successful and that the one hand is in fact more firmly clutched than the other. A position of constant internal rotation of the arm together with a tendency to pronation of the forearm may also be noted, as well as a position of flexion of the elbow. When these findings are coupled with a history of a difficult birth, brachial palsy is the diagnosis. Fourth,

can be delayed until 6 years of age or more. Constrasted with this, if the digits are anaplastic (Fig. 2) or if the terminal soft tissue defect will retard subsequent growth, operative releases should be instituted earlier, that is, within the first



Fig 1.—*A*, Syndactylism involving the third and fourth digits; *B*, syndactylism before operation; *C*, syndactylism following operation

two years of life. In general the surgical result will be better in any type of defect if repair can be delayed until the growth increment in any component part can be determined, since any surgical scar will be less likely to thwart growth of itself.

spina bifida with meningomyelocele, a condition to keep in mind, is ordinarily easy to diagnose It may be associated with varying degrees of weakness and deformities of the lower extremities. Fifth, there is a group of more or less unusual conditions, but diagnosis is ordinarily easy because they are so obvious to inspection. Such conditions are congenital deformities and consist of entities such as web fingers and toes, absence of parts, accessory parts, and others.

Congenital deformity or deformities are likely to occur in the general population in 5 7 children of every 1,000. Of all the embryonic defects known to occur, approximately 11 per cent will be manifest in bones, muscle, and skin. The defects which will come to the attention of the orthopedic surgeon are as varied as the scope of the imagination. There is no intent to discuss here the myriad variants which are known in this field, but rather to give helpful hints relative to causative factors and predictable occurrence rates, to describe the commoner defects, to aid the family doctor in sorting out those defects which can be benefitted by treatment, and to suggest the proper time to institute such treatment.

Certain factors are known to produce embryologic defects experimentally and may have application in the case of the human being. Measles occurring in a mother during gestation is the best-known example. X-ray radiation if given in the first three weeks of gestation will certainly produce embryologic aberrations. Dietary deficiencies at specific periods of gestation, lowered oxygen tension for any sustained time, and combined chemical and/or mechanical insults, such as insulin injections into the embryo, are all productive of fairly predictable defects in the fetus. Older beliefs, such as the month conception occurs or abnormal placental implants, are unlikely to have a bearing in the production of embryologic defects On the other hand, the chance of a defect occurring in the offspring of a mother past 30 years of age after a long period of sterility is three to four times greater than that in normal incidence. Similarly, after the birth of one child with a defect, the incidence of defect in subsequent children born to such mothers is eighteen times greater than in the population at large.

As an aid to easy reference, the more common deformities are presented with an illustration and pertinent discussion, somewhat in the order of their rate of occurrence. We have taken the liberty of giving the reader a general consensus regarding therapy. No area of orthopedic surgery requires more experience and ingenuity to overcome the handicaps, both functional and cosmetic, that may result from congenital abnormalities of the bones, joints, and connective tissues of the body. We feel it is the duty of every physician attending a birth to give the infant a thorough examination for deformities not only to discover any defects, but also to avoid later embarrassment when parents are likely to ascribe unlabelled deformities to birth injury. Clubfoot, congenital dislocation of the hip, and congenital torticollis are described elsewhere. (See pages 34, 67, 99.)

Deformities of the Hands and the Fingers

Syndactylism.—Syndactylism is the simplest type of deformity. (Fig. 1, *A*) If the fingers within the webbed area have good motion and well-formed joints, there is no rush to institute therapy, and operation as outlined in Fig. 1, *B* and *C*,

Synostosis Between the Radius and the Ulna.—Usually, synostosis between the radius and the ulna is bilateral, and detection is possible only by a careful test for absence of pronation and supination. Infants and children are so adept at substitute motions to overcome such loss that this defect is not uncommonly discovered incidentally. Surgical attempts at relief of synostosis do not offer a highly hopeful outcome. Perhaps the best management of the condition is resection of the upper end of the radius after bone maturity, or at least an osteotomy to obtain a more favorable fixed position.

Congenital Defects of the Spine

Hemivertebra.—The physican is alerted to a defect in the spine ordinarily by a deformity which either is present at birth or develops soon therafter. Hemivertebra (Fig. 4) can be mild and cause a deformity which is easily compensated for by the remainder of the spine, or it can be more severe (Fig. 5) with an almost certain permanent deformity which can be of considerable proportion. Treatment of either condition is equivocal inasmuch as the former reaches a stopping point short of handicap, and no therapy, including spinal fusion, in the latter can yield a predictable result. Should a fusion operation be elected as treatment, it would be most effective between 3 and 5 years of age.

Spina Bifida.—Obvious bifid or undeveloped vertebral rings are associated with meningocele (Fig. 6) and the outpouching of the canal contents. This condition demands early evaluation and treatment by a neurosurgeon. There is no treatment for spina bifida per se. The less obvious spina bifida occulta is ordinarily diagnosed by x-ray and not discovered until later in childhood when sensory losses or foot deformities are noted.

Klippel-Feil Syndrome.—The rare condition of Klippel-Feil syndrome is included here since it involves the cervical spine. (Fig. 7). Attention is focused on this area because of a proportionately short, thick neck, a condition which may show itself later since it is not always detectable at birth. There is no treatment available which can change the course of the defect, and as a rule it amounts to a cosmetic rather than a functional loss even though cervical spine motions are limited.

Rib Defects

Rib defects are mentioned because they frequently accompany abnormalities of the spine. (Fig 8.) Occasionally an absence of a portion of rib will be the only known deformity—an alarming one to parents (Figs. 9 and 10.) No treatment except reassurance is necessary as a rule.

Chest Excavatum

If the chest funneling (chest excavatum) is severe (Fig. 11), it should be brought to the attention of a chest surgeon soon after birth. By and large, an early release of the congenital band from the sternum to the spine will be all that is necessary in the way of treatment.

(Text continued on page 22)

Variants, such as polydactylism, represented by an anaplastic extra finger, can be corrected within the first few weeks of life. More severe defects (Fig. 3) require more careful thought and examination, and correction time should be from 2 years of age upward, depending on growth, deformity, function, and the reconstruction possibilities as determined by the consulting surgeon.

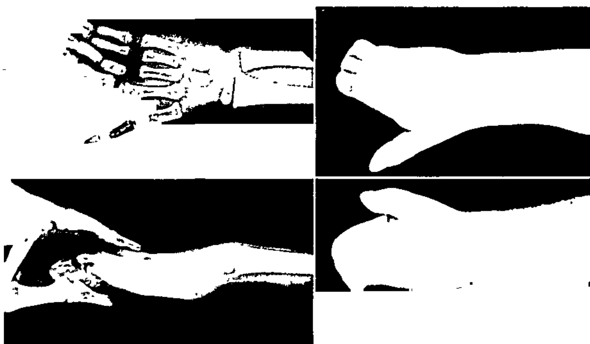


Fig 2 —Anaplastic digits Operative releases are indicated within the first two years of age



Fig 3 —Severe degree of deformity involving the bony bridging between the third and fourth digits

Clubhand.—Clubhand is usually associated with absence of the radius and because of this is difficult to manage Early manipulation and splinting as a rule result in little correction Surgical restoration gives, at best, only partial relief, and, after bone maturity, wrist arthrodesis will keep the hand in alignment with the forearm.



Fig 6—Spina bifida with meningomyelocele. Note atrophy of the lower extremities and the associated deformities of the foot.



Fig 7.—Klippel-Feil syndrome.



Fig. 4.—Congenital hemivertebra with compensation by the remainder of the spine



Fig 5 —Congenital deformities of the vertebrae severe enough to result in permanent deformity

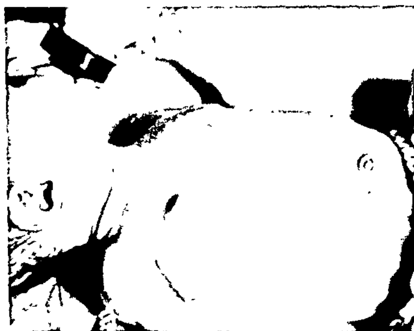


Fig. 10—Deformities of the ribs.



Fig. 11.—Funnel chest.



Fig 8.—Congenital defects of the ribs. Note absences, fusions, and irregularities in the contour.



Fig 9 —Deformities of the ribs.

the calcaneovalgus deformity will always correct itself spontaneously. The correction can be hurried by daily manipulation of the foot toward a neutral position.

Polydactylism.—The problem of polydactylism in the foot is somewhat different from that occurring in the hand. The main handicap is distortion of the foot which makes the wearing of shoes difficult. (Fig. 13.) The condition requires amputation of the accessory toes, along with their metatarsals if present.





Fig 14.—Polydactylism associated with clubfoot.

This is most effective if done between 3 to 5 years of age, since development up to a point is necessary to determine which are rightful and which are accessory rays. Accessory rays are likely to lag in development. When polydactylism occurs in association with other deformity in the foot, such as clubbing (Fig. 14), each deformity must be treated individually except where one deformity may interfere with the progress of treatment in the other, in which case operative interference may need to be hastened.

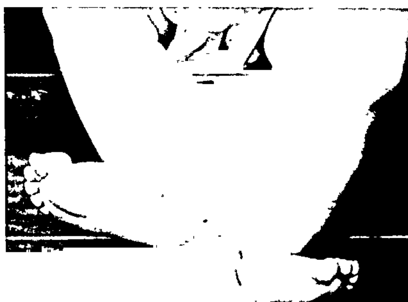


Fig. 12.—Calcaneovalgus deformity of both feet.



Fig. 13.—Polydactylism of the foot.

Lower Extremities

Calcaneovalgus.—Probably as a result of intrauterine position, newborn infants quite commonly will show a severe calcaneovalgus position of a single foot. (Fig. 12.) This is often mistaken for a clubfoot and should not be, since

Congenital Pseudarthrosis of the Tibia.—Congenital pseudarthrosis of the tibia is depicted in Figs. 17 and 18 which show the pseudarthrosis to be well developed by 2 years of age. This condition can easily escape detection at birth unless careful search is made because of the suspicion aroused by a slight or mild anterior bowing in the lower one third of the leg. X-ray pictures at the time of earliest bowing will not disclose the discontinuity of the bone because it becomes evident only as the condition develops. Because of the possibility of progression, a cautious prognosis should be made in the case of very mild deformities of the lower end of the tibia. The correction of the pseudarthrosis is not always successful, but certainly an attempt by bone grafting should always be made, since the



Fig. 17 —Congenital pseudarthrosis of the tibia.

chance for success of a "good take" of the graft increases as the child reaches puberty. On the other hand, the sooner the leg can bear weight, the sooner a decrease in the shortening process will occur. A reasonable time to attempt to obtain union is at 6 years of age.

Congenital Absence of Bones.—Absence of the upper one third of the femur or shortening of the femur due to abnormality of formation and growth of the hip joint (Fig. 19) are frequently combined with absence of the fibula, a short-bowed tibia, and a small foot. As growth proceeds, the leg length lags on the involved side, and the foot shifts into a deformity of equinus, with or without valgus. At walking age it is mandatory to supply some form of support,

Calcaneal Astragalar Synostosis.—The accessory joint present in calcaneal astragalar synostosis (Fig. 15) will not be noted at birth but may show itself as peroneal spasm with flat or valgus foot deformity, with limp and pain, at about 5 to 7 years of age and should be kept in mind should these symptoms develop. The treatment is excision of the abnormal articulation between the calcaneus and the astragalus.



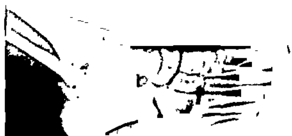


Fig 15 —Calcaneal astragalar synostosis.



Fig 16 —Congenital cockup of the fifth toe

Congenital Cockup of the Fifth Toe.—Cockup of the fifth toe is a common deformity (Fig. 16) which occurs bilaterally and can be found in various members of a family. It is harmless except when rubbed excessively by shoes. When and if it causes difficulty, it can be relieved by various operations.

usually an ischial weight-bearing brace with a built-in platform for the foot. As soon as the child is able to walk, thought should be focused on a long-term program of correction, which frequently includes surgical efforts to correct foot deformity and to provide hip stability. Dependent on the success of these efforts, the ultimate solution may be amputation below the knee at a suitable level and application of a prosthesis which will make up for any leg-length discrepancy.

Circumferential Contractures

Circumferential contractures, or so-called amniotic band constrictions, are not uncommon. (Fig. 20.) These are encountered more frequently perhaps in the legs but can occur also in the upper extremities. They are, as a rule, quite



Fig. 20.—Circumferential contractures (amniotic band constrictions) involving both legs.

obvious and become more so with the growth of the infant. Because the indentation is produced by fibrous tissue in the deep fascia and because this fibrous tissue acts like a constricting band, the condition should be remedied soon after 1 year of age. Correction can be attained by complete excision of the thickened fibrous band.

Diagnoses Common at 6 Months to 2 Years of Age

During the period when a child is 6 months to 2 years of age a different group of affections may become apparent, although certainly most of them have arisen long before they are commonly called to the attention of the physician.

Congenital Dislocation of the Hip

Not too long ago, the diagnosis of congenital dislocation of the hip was not made much before the average age of 18 months, that is, at an age at which parents became disturbed because the child would not walk or at which the parents noted



Fig. 18.—Congenital pseudarthrosis of the tibia.



Fig 19.—Abnormal development of the upper femur and absence of the fibula. Note especially the relation between the upper femur and the acetabulum.

Osgood-Schlatter's Disease

If a *boy* 9 to 14 years of age is presented with the complaint of "pain and swelling of the knee" which by actual indication by the patient is not in fact in the knee, but rather at the site of the tibial tuberosity just below the knee, the presumptive diagnosis is Osgood-Schlatter's disease (osteochondritis of the tibial tuberosity). Tenderness to palpation in this area and pain upon kneeling, squatting, or mounting and descending stairs, together with roentgenograms revealing fragmentation of the epiphysis of the tibial tuberosity, confirm the diagnosis.

Slipping Capital Femoral Epiphysis

It has been pointed out previously that a girl 6 to 18 months of age with a limp is probably suffering from congenital dislocation of the hip and that a boy 4 to 8 years of age with a limp is considered to have Legg-Perthes' disease of the hip. Now we consider the fat boy, 9 to 14 years of age, who walks with a limp and/or complains of hip or knee pain. These basic facts, in addition to findings of limitation of internal rotation of the lower extremity at the hip, with or without shortening of the leg, call for the supposition that the patient has slipping capital femoral epiphysis. Roentgenograms will probably confirm the diagnosis.

Achilles Tendon Bursitis

Although it is possible for the hard heel counter of a shoe to rub upon the Achilles tendon at any age consistent with the wearing of firm shoes, nevertheless Achilles tendon bursitis is noted with special frequency in the 9-year to 14-year age group Findings are tender swelling and redness and roughness of the skin over the Achilles tendon at its junction with the os calcis.

Diagnoses Common at Any Age From Birth to 14 Years

Thus far, in order to simplify diagnostic thinking, a number of conditions, grouped as to the age at which they are most likely to be manifest, have been presented. However, certain disturbances remain which can and do occur at varying ages in childhood These are as follows: (1) acute hematogenous osteomyelitis, (2) acute suppurative arthritis, (3) acute anterior poliomyelitis, with all of its several possible locomotor manifestations, (4) discrepancies in leg length which have a variety of underlying causes, such as poliomyelitis, congenital dislocation of the hip, Legg-Perthes' disease, slipped capital femoral epiphysis, etc , (5) acute rheumatic fever, (6) rheumatoid arthritis, and (7) tuberculosis. It is of note that the disturbances which become apparent at any age or at various ages, contrary to the conditions heretofore mentioned, are in the main associated with systemic illness.

A child of any age who has an elevated temperature, appears systemically ill, and has pain and swelling around a major joint should be considered to have acute hematogenous osteomyelitis and/or acute suppurative arthritis.

A child who has an elevated temperature, appears sick, and has pain and swelling around a major joint might have rheumatic fever *provided* septic joint and acute osteomyelitis have definitely been ruled out.

and the different height of the shoulders become obvious during ambulation). Diagnosis can be made by roentgenogram, but the physician should be aware of the age at which this complaint is likely to be brought to his attention.

Diagnoses Common at 4 to 8 Years of Age

Legg-Perthes' Disease

A complaint of a painless limp, of a pain in the hip, or of pain in the knee (knee pain is often in the nature of referred pain from the hip) occurring in an otherwise healthy boy 4 to 8 years of age should arouse the immediate suspicion of Legg-Perthes' disease of the hip. Legg-Perthes' disease is osteochondritis of the femoral head. In the first six to eight weeks following the onset of the complaint a definite diagnosis may be impossible since roentgenograms at this time may be negative. Yet this history in a *male* of the average age of *7 years* is so suggestive of Legg-Perthes' disease that repeated examinations and roentgenograms should be made at monthly intervals until diagnosis is established.

Diagnoses Common at 9 to 14 Years of Age

Calcaneal Apophysitis and Freiberg's Infraction

In children with foot complaints in this age group, calcaneal apophysitis and Freiberg's infraction should be kept uppermost in the mind. Both of these conditions are in the nature of osteochondritis. A painful heel coupled with a tendency to walk on the tiptoes, especially in a *boy* 9 to 13 years of age, with tenderness to palpation over the back part of the heel (epiphysis of the os calcis) most likely means calcaneal apophysitis. Roentgenograms will probably reveal the increased density and the fragmentation characteristic of the disturbance.

If the complaint is pain in the metatarsal area in a *girl* 9 to 14 years of age, the physician will probably find swelling around the head of the second metatarsal head and tenderness to pressure at this site. The primary diagnosis is osteochondritis of the second metatarsal head (Freiberg's infraction). Fallen metatarsal arch should not even be thought of until after the roentgeongrams have ruled out Freiberg's infraction.

Idiopathic Scoliosis and Osteochondritis Juvenilis Deformans

In the 9-year to 14-year age group there are two important disturbances of the back, one occurring in girls and the other more common in boys. In the case of a girl of this age whose parents state that she has one hip higher than the other or that she has a "curvature of the spine," the doctor's first thought in diagnosis should be idiopathic scoliosis. Diagnosis is simply made by inspection of the back and observation of the scoliotic deformity. Roentgenograms will confirm the diagnosis.

Pain in the back in a boy 9 to 14 years of age can be presumed to be due to osteochondritis juvenilis deformans unless the roentgenograms prove the existence of some other condition.

Age		Condition	Page
Birth to 14 yr.	(1)	Acute hematogenous osteomyelitis	360
	(2)	Suppurative arthritis	366
	(3)	Anterior poliomyelitis and its residual locomotor disabilities	107
	(4)	Leg-length discrepancy	84
	(5)	Rheumatic fever	366
	(6)	Rheumatoid arthritis	366
	(7)	Tuberculous arthritis	366

Keeping in mind then the general age distributions of the orthopedic disturbances in childhood, we will take up the discussion of the conditions according to the presenting complaint for each anatomic location.

DISTURBANCES OF THE FOOT AND ANKLE IN INFANCY AND CHILDHOOD

Complaint		Likely Diagnoses	Page
Foot deformed Feet turn down and in Clubfoot	(1)	Clubfoot (congenital talipes equinovarus)	34
	(2)	Congenital neurologic clubfoot (spina bifida, peripheral nerve palsies)	39
	(3)	Acquired neurologic clubfoot	53
	(4)	Post-poliomyelitic deformities	53
Walks on tiptoes	(1)	Cerebral palsy (spastic paralysis)	39
Feet appear flat Stumbling Aching in feet Pain in calf muscles	(1)	Pronation of foot	41
Pain in long arch of foot	(1)	Köhler's disease (osteochondritis of tarsal scaphoid)	43
Toes in Pigeon-toed Trips over feet	(1)	Adduction of forefoot	43
	(2)	Medial torsion of tibia	45
	(3)	Inadequate external rotation of knees	46
	(4)	Inadequate external rotation of hips	46
Painful metatarsal arch Pain and swelling at base of second toe	(1)	Freiberg's infraction (osteochondritis of second metatarsal head)	46
Painful swollen ankle, with elevation of temperature Limp	(1)	Suppurative arthritis	48
	(2)	Acute hematogenous osteomyelitis	49
	(3)	Rheumatic fever	50
	(4)	Rheumatoid arthritis	51
	(5)	Tuberculous arthritis	51
Painful heel	(1)	Calcaneal apophysitis	51
	(2)	Achilles tendon bursitis	52
Weak foot Foot drop Weak and deformed foot	(1)	Post-poliomyelitic deformities of foot and ankle	53

At any age, a child who has fusiform swelling and pain in the proximal interphalangeal joints of the hands probably has one or another form of rheumatoid arthritis

A child appearing chronically ill and wasted, with mild elevation of temperature and a long-standing indolent swelling of a painful joint, probably has tuberculosis

In the age group from birth to 14 years, a child who has headache, experiences nausea and vomiting, and complains of a stiff neck or back should be examined for evidences of muscle weakness consistent with anterior poliomyelitis. The residuals of the paralysis, long after the acute disease is over, may be the presenting complaint

In contrast to the conditions which occur at any age and which are systemic diseases, leg-length discrepancies occur at a great number of ages, chronologically speaking This is consistent with the fact that several different conditions can be the underlying difficulty, and the discrepancy in leg length arises, therefore, at the age at which the particular etiologic factor is most commonly operative.

Since most physicians will find it easy to think in terms of a different set of conditions at different age levels, some of the more common conditions that affect certain age groups are listed as follows·

Age		Condition	Page
At birth	(1)	Clubfoot (congenital talipes equinovarus)	34
	(2)	Congenital torticollis	99
	(3)	Brachial palsy	102
	(4)	Spina bifida and meningomyelocele	17
	(5)	Obvious but more unusual anomalies such as absence of parts, accessory parts, web fingers, etc.	14
6 mo. to 2 yr	(1)	Congenital dislocation of hip	67
	(2)	Cerebral palsy	111
	(3)	Rachitic deformities	57
	(4)	Congenital bowing of tibia or femur	56
	(5)	Congenital or developmental genu valgum	58
2 to 4 yr	(1)	Pronation of foot	41
	(2)	Adduction of forefoot	43
	(3)	Medial rotation of tibia	45
	(4)	Inadequate external rotation of knees	46
	(5)	Inadequate external rotation of hips	46
	(6)	Pseudoparalysis of arm due to trauma	107
	(7)	Kohler's disease	43
	(8)	Congenital scoliosis	17
4 to 8 yr	(1)	Legg-Perthes' disease	74
8 to 14 yr.	(1)	Calcaneal apophysitis	51
	(2)	Freiberg's infraction	46
	(3)	Idiopathic scoliosis	91
	(4)	Osteochondritis juvenilis deformans	96
	(5)	Osgood-Schlatter's disease	59
	(6)	Slipping capital femoral epiphysis	76
	(7)	Achilles bursitis	52

rotation of the limb bud may be responsible for congenital dislocation of the hip. The latter is associated with talipes equinovarus more frequently than is possible by chance alone. Add to this the observation that frequent nodulations or neuromas may be found around the peripheral nerves of patients with various types of congenital anomalies, including clubfoot, and it seems best to discard the theory of uterine pressure. In other words, the process is more subtle and more complicated than merely the result of the deforming influence of pressure by the uterine wall.

Anatomically, talipes equinovarus can be described in this manner. The fascia, tendons, and muscles on the medial side of the foot are contracted and shortened, and on the lateral side of the foot they are lengthened. Special note should be made of the fact that the Achilles tendon is shortened. The mortise of the ankle posteriorly is narrower than normal, thus forcing the talus foward. Roentgenograms of the deformed foot show that the calcaneus and talus are lined up in a sagittal plane, rather than in divergent positions in the form of a "Y" as they appear in roentgenograms of the normal foot. The scaphoid bone is situated medially on the head of the talus rather than in front of the talus, as is normal. The bones of the foot (composed largely of cartilage in the infant) are deformed somewhat, depending on the shape of their abnormal position. The tibial shaft may have a medial twist.

Treatment of talipes equinovarus in the young child undertakes to stretch the contracted soft parts and to deposit the bones in their normal position. It can not be sufficiently stressed that the optimum time to begin treatment is at birth If intelligent and adequate therapy is begun at birth and is persistent, good results are obtained in about 90 per cent of the cases. The longer treatment is delayed after birth, the more difficult correction becomes and the less chance there is of maintaining correction. The older the child, the tighter the contractions become and the more likely the bones are to assume a deformed shape. The older the child when therapy is first instituted, the more likely that operative measures rather than corrective casts will be necessary. *Children do not "outgrow" clubfoot!* If the parents wait for the deformity to correct itself, precious time which should have been used for proper treatment is lost. If the condition is detected at birth, one acceptable method of correction is the use of repeatedly applied plaster casts. (Fig. 22.) The cast is applied from the high thigh, with the knee in flexion, and extended down over the foot. As the plaster drys correction is obtained by manipulation. Entire correction cannot ordinarily be obtained at first. It is necessary to achieve results by stages. The manipulation should be done along specific lines.

First, correction of the adduction of the forefoot should be instituted by attempting to abduct the forefoot. This movement attempts to bring the scaphoid bone from its abnormal medial position to around in front of the head of the talus.

Second, the inversion should be corrected by eversion of the entire foot. The talus and calcaneus are unlocked by the eversion by their position in the sagittal plane. Thus, the talus and calcaneus, as shown on the roentgenograms, now diverge from each other in the form of a "Y", as they should.

Clubfoot (Congenital Talipes Equinovarus)

There are numerous types of clubfoot. Some are both congenital and neurologic while others are purely neurologic. The common type is congenital and is called by various names descriptive of the deformed position the foot assumes Most frequently the term "talipes equinovarus" is applicable to the congenital clubfoot. Talipes equinovarus means literally an ankle foot in which there is plantar flexion and inversion of the foot. The term "ankle foot" is used because those with this type of clubfoot actually attempt to bear weight on the lateral border of the foot and ankle rather than on the sole of the foot. There may be four components to the deformity of talipes equinovarus. (Fig. 21.) It must be emphasized that all four may not be present, or at least present to an appreciable degree, for the foot to be classified as talipes equinovarus. These



Fig. 21 —Bilateral clubfoot (From Larson, C. B , and Gould, M Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co)

four components are (1) plantar flexion of the foot, (2) inversion of the foot, (3) adduction of the forefoot, and (4) medial rotation of the tibia. The first three of these are often unaccompanied by the fourth. At times any one of the four may exist alone, or any combination of the four may be found. The deformity, which may affect both feet, is discovered at birth. Thus, it is called congenital. There are many theories as to the cause of clubfoot. Some believe that the deformity is due to constant pressure of the uterine wall on the foot of the fetus, which is held in a bad position. This idea has not nearly so much to support it as has the one which emphasizes the possible role of limb bud rotation in congenital deformities. During fetal life, the normal foot passes through and beyond all stages anatomically characteristic of talipes equinovarus. Improper

untreated until 4 years of age, little can be hoped for from conservative therapy. It is at this point that the physician faces a difficult decision and probably had better seek expert advice.

An operative procedure which is commonly used in treatment of talipes equinovarus in the young child is the lengthening of the Achilles tendon. It will be recalled that one of the components of the deformity is equinus due to a tight heel cord. Often the equinus can be overcome by the use of passive stretching. If it cannot, surgical lengthening is used. An incision is carried out vertically, just to the side of the Achilles tendon, exposing the tendon. Numerous possible ways of lengthening the tendon are available. One satisfactory way is to make a long oblique cut through the tendon from above downward, starting at the deep aspect of the tendon proximally and ending at the superficial aspects of the tendon distally. Another method is the "Z" plastic type of cut in the tendon; that is, the tendon is split longitudinally for the desired distance, and then one cut is made from one side proximally to meet the longitudinal cut and another cut is made from the other side distally to meet the longitudinal cut. Roughly, a Z-shaped incision is thus made. Whichever way the tendon is divided, the foot is then forced into dorsiflexion until the deformity of equinus is corrected. The cut ends of the tendons are then sutured, but the tendon must remain loose and relaxed even when the corrected position is obtained. Following wound closure, the cast is applied. At times, even after complete division of the tendon, correction of the equinus is impossible. This circumstance indicates that the posterior capsule of the ankle joint is probably contracted. Consequently, posterior capsulotomy of the ankle, in conjunction with tendon lengthening, is done, if it appears necessary.

If treatment is not begun until the child is 10 to 12 years of age then a triple arthrodesis is usually performed. The term triple arthrodesis is used because three joints (Fig. 23) of the foot are fused. They are (1) the subastragalar joint between the astragalus and the calcaneus, (2) the astragaloscaphoid (or taloscaphoid) joint between the astragalus and scaphoid on the medial side of the foot, and (3) the calcaneocuboid joint between the calcaneus and cuboid on the lateral side of the foot.

The procedure is carried out in the following manner. Through a curved anterolateral incision over the foot, the subastragalar, calcaneocuboid, and taloscaphoid joints are exposed. The articular surfaces of the subastragalar joints are excised by an osteotome All the articular cartilages are removed from both the inferior surface of the talus and the superior surface of the calcaneus. Next, the articular surfaces between the head of the talus and the scaphoid bone are excised by an osteotome. Last, excision of the joint between the calcaneus and the cuboid is performed. It is well to remember that the deformity is mainly one of adduction and inversion. Thus, it is easily seen that to correct the deformity, it is necessary to remove a wedge of bone from each of the three joints, with the base of each wedge in a lateral position. After removing the wedges of bone, raw, bleeding bone should be approximated to raw bone at all three sites. Then the wound is closed, and the cast is applied. This stabilizing procedure wipes out the inversion and eversion of the foot (which take place at the sub-

Last, the equinus deformity is corrected by placing the foot in dorsiflexion. Care must be taken to put the *entire* foot into dorsiflexion. Otherwise, the foot might bend at the mediotarsal joints and result in a so-called "rocker bottom" foot.

After the normal position has been achieved, the foot is not uncommonly put into an overcorrected position. This position consists of exaggerated abduction of the forefoot, eversion, and dorsiflexion.

Casts are left on for two weeks, after which they are changed, and new ones are applied in a few days. The total length of time for a series of casts will depend upon the severity of the deformity, the ease or difficulty of correction, and the tendency of the condition to recurrence. Perhaps casts should be applied every two weeks for several months. The feet should be observed thereafter at regular intervals until the patient has walked and has shown no tendency for the deformity to return. During this period of discontinuing the casts and the beginning of weight-bearing, the feet may be protected by plaster splints at night.

Other methods of correction of talipes equinovarus, such as the Denis Browne splint, have been used. This metal splint is constructed usually in three sections.

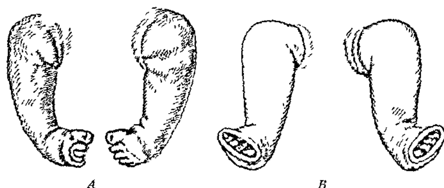


Fig 22—Bilateral talipes equinovarus in infant *A*, Before correction; *B*, undergoing correction in plaster casts. (From Shands, A R, and Raney, R. B. Handbook of Orthopaedic Surgery, 1957, The C V. Mosby Co)

There are two small metal plates which are applied, one to the sole of each foot. The third piece is a curved bar which extends from one foot to the other. There are several holes in the long, curved metal bar in order that the metal footplate may be adjusted in a number of positions of abduction and external rotation of the foot. The method has the advantage of maintaining the muscles in good condition.

Another common method of correction of clubfoot is by use of wedge casts. Casts are applied to the foot with no particular effort to achieve correction while the plaster is drying. Later, a wedge is cut from the lateral aspect of the cast, and a slit is made in the cast on the medial side. The cast is then wedged slowly and progressively into a position of correction. In using this method, care must be exercised to avoid pressure sores

If a clubfoot has been neglected until the child is 2 years of age, it is exceedingly difficult to correct by conservative means. If the patient has remained

one of the important factors in causing persistence of the foot deformity. If it is present, derotational osteotomy of the tibia will occasionally be necessary to correct it.

In summary, *congenital* talipes equinovarus is a deformity discovered at birth and characterized by contractions of the soft tissues and by malposition of the bones of the foot. Clinically the foot is held in equinus at the ankle (that is, in plantar flexion). The entire foot is inverted, and the forefoot is abducted. The tibia may have a medial torsion throughout its length, so that the ankle and foot face medially toward the midline. One, several, or combinations of the deforming components may be observed. The condition is best treated by the use of manipulation and casts, if treatment is begun early. If treatment is delayed, numerous operative measures are available. Lengthening of the Achilles tendon is an operation which is done either alone or in conjunction with other methods, as indicated by existing conditions. Triple arthrodesis is another procedure available for correction in later life.

Congenital Neurologic Clubfoot (Spina Bifida, Peripheral Nerve Palsies)

A child born with congenital spina bifida and meningomyelocele may have varying degrees of paralysis in the legs and feet. Associated with the paralysis is one type of clubfoot. Peripheral nerve palsies, unassociated with spina bifida, occasionally occur at birth and are responsible for certain types of clubfoot. Deformities of the foot also occur in children suffering from spastic paralysis. The congenital neurologic clubfoot may be managed by casts until the child is old enough to wear corrective braces. It is possible to perform tendon transplants and arthrodesis on patients with congenital neurologic clubfoot, but the prognosis is not so favorable as in congenital clubfoot unassociated with neurologic disturbances. The tendency for the return of the deformity in patients with neurologic clubfoot is great.

Acquired Neurologic Clubfoot

For information on acquired neurologic clubfoot, see the discussion on Anterior Poliomyelitis (pages 53, 107).

Summary of the Types of Clubfoot

It should be apparent that a deformity of the foot may have different causative factors. The common types are congenital clubfoot and clubfoot due to muscle imbalance following anterior poliomyelitis. Clubfoot may also accompany spina bifida, cerebral palsy, and other nerve injuries. One should, of course, determine the type presented, since the prognosis and treatment are influenced by the type of clubfoot to be corrected.

Cerebral Palsy (Spastic Paralysis)

Usually children afflicted with cerebral palsy have so many complaints which concern so many systems of the body that the ordinary complaints will

astragalar joint), and it reduces the adduction and abduction of the forefoot, a great deal of motion of which occurs at the calcaneocuboid and taloscaphoid joints. The ankle motion, of course, is not altered.

In general, the results of a triple arthrodesis are satisfactory. However, certain features should be pointed out. The procedure should not be done at too early an age. If it is performed on too young a child, there will be more cartilage than bone present in the foot. Therefore, excision of excessive amounts of tissue may be necessary in order to reach bone, and the chance of failure of

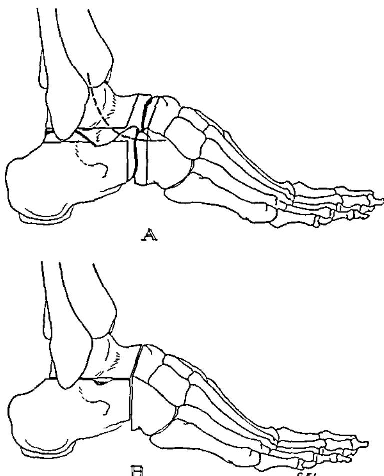


Fig. 23.—Triple arthrodesis. *A*, Line of skin incision, shaded area indicates amount of bone removed, *B*, completion of operation. (From Speed, J. S., and Knight, R. A.. Campbell's Operative Orthopaedics, 1956, The C. V. Mosby Co.)

the arthrodesis per se is greater if large amounts of cartilage are present. Therefore, it is wiser to wait until the child is at least 11 or 12 years of age. Growth is another factor which probably may adversely affect the results of a triple arthrodesis. Sometimes good correction is maintained for a year or so following the operation, but gradually deformity reappears; that is, seemingly as the child grows, the deformity redevelops.

If correction of the clubfoot is not being obtained as readily as it should be or if recurrence of the deformity appears likely, it is well to review the examination to determine whether medial rotation of the tibia is present. It can act as

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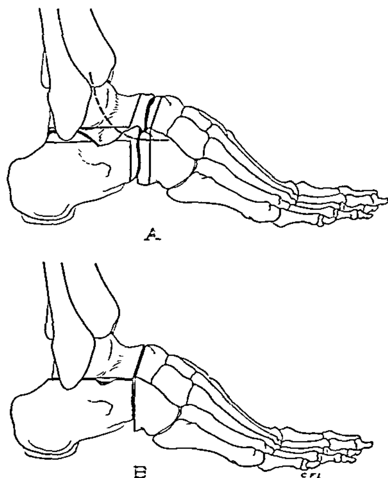


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The local conditions of the foot and ankle can be treated in various ways, although the picture of the child as a whole should certainly be considered. Thought should be given to whether the child falls within the category of patients who need more general help than simple orthopedic management of the difficulty in gait, which is the result of spasticity of the gastrocnemius muscle. The spastic equinus deformity should be stretched passively several times during the day by the parent. Molded plaster splints, allowing as much dorsiflexion at the foot and ankle as possible, can be used for night casts while the child is asleep. It is well to bring the night cast well above the knee and, at the same time as the foot is in dorsiflexion, to place the knee in as much extension as possible. The reason for this is that the heads of the gastrocnemius arise from above the knee joint itself, and if the knee joint is allowed to relax while the ankle is in dorsiflexion, a great deal of the therapy is negated. Instead of night casts, appliances can be used. Such appliances essentially consist of metal plates to be attached to the sole of the shoe and a leg brace with adjustable turnbuckles on the side to allow progressively more dorsiflexion week by week.

During the day, the child may wear a brace on the leg which can be locked at right angles at the ankle, or he may wear a spring brace similiar to that used in the treatment of the foot-drop position common in post-poliomyelitis. This spring brace helps to bring the foot into dorsiflexion at each step.

If the conservative program fails to bring results, operative measures should be considered. Only those physicians with rather extensive experience in this field are qualified to make the decision as to whether operative intervention is indicated. Operative intervention in spastic paralysis may, many times, produce bad results in what appeared at first to be a very simple condition. The possible operative measures for spastic paralysis of the lower extremities are lengthening of the Achilles tendon with or without posterior capsulotomy of the ankle joint, neurectomy at the popliteal fossa, or obturator neurectomy.

Neurectomy performed at the popliteal fossa is, in essence, as follows. The sciatic nerve is exposed in the popliteal fossa, and the two motor branches to the two heads of the gastrocnemius-soleus group are isolated and tested to confirm that they are, in fact, the motor nerves to these muscle heads, and then they are severed. In this way, the strength of the gastrocnemius is reduced roughly by two thirds.

The obturator neurectomy is accomplished by an intrapelvic approach. The obturator nerve is exposed on the lateral wall of the pelvis at a point just before it emerges from the pelvis into the leg and tested to confirm that it is the motor nerve, and then it is severed. It should be pointed out that obturator neurectomy is performed in spasticity of the lower extremity only if the spastic paralysis is severe enough to involve the entire lower extremity, including the adductors of the thigh, the flexors of the knee, and the plantar flexors of the foot and ankle.

Pronation of the Foot

It is significant in pronation of the foot that often the complaint is not about any pain the child is experiencing, but rather that the child's feet appear to be flat. The parent may complain simply that the child stumbles easily or is awk-

be of locomotor function as a whole. That is, the parents will state that the child cannot sit, does not stand, cannot walk, or cannot balance himself. However, in some of the relatively mild cases, the whole process may have escaped notice until the parent presents the child to the doctor with the simple complaint that the child walks on tiptoe. (Fig. 24.) Under such a circumstance, a history should be taken to elicit information regarding evidence of difficulty during pregnancy, difficulty at the time of delivery, difficulty of resuscitation of the child at the time of delivery, episodes of cyanosis during the newborn period,

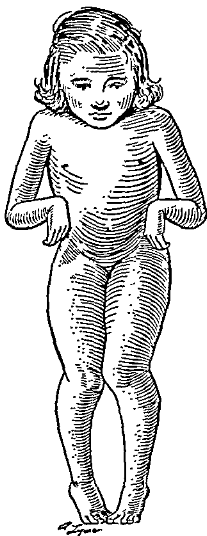


Fig. 24.—Cerebral palsy with spastic quadriplegia Flexion at all joints except the ankles. Adduction and internal rotation of the thighs "Scissors" gait. (From Larson, C. B, and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

and similar information. Such a history should be of help in making the diagnosis of spasticity or spastic paralysis of either one or both lower extremities. Examination of the child will reveal that he has difficulty in bringing the ankles into normal dorsiflexion and that a stretch reflex is present at the ankle. It may also be noted as a corollary that the knees and hips likewise will show muscle tightness upon passive motion. The knees will not be extended as well as normal, and the legs will not be abducted at the hips as well as normal.

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ward in walking and that in association with his awkwardness, the child's feet appear to be flat. In other instances, however, the parent will state that the child has complained that his feet hurt him. Also, it is common that the child has awakened at night complaining of pain in his calf muscles. Examination will show that the long arch of the foot is depressed and low, and inspection of the foot from behind reveals that the os calcis is rotated on its longitudinal axis more than normal. The forefoot tends to be held in abduction. It is well to keep in mind that a child's feet are likely to carry rather heavy fat pads and, therefore, apparent depression of the long arch alone is not enough to justify a diagnosis of pronation of the foot. The most reliable sign is the rolling appearance of the os calcis, associated with abduction of the forefoot.

Children's feet are relatively flexible and mobile, and it might be supposed that the pronation could be corrected by exercises. (The adult foot is much more rigid, and exercises would appear to offer little hope of correction.) The physician is then undecided, when treating a child's foot (especially if the condition is asymptomatic), whether supports should be ordered, exercises should be advised, or simple reassurance to the parents should be given. It should be emphasized that we are speaking of excessive pronation, since a certain amount of pronation is normal. It is our opinion that if any chance of permanent correction by exercises is feasible, it will be during childhood. If it is worth while for the child to engage in exercises, it is also worth while for him to use support for the foot. Therefore, an innersole for the shoe which supports the longitudinal arch should be recommended and foot exercises should be taught. The innersole should be constructed of rubber covered with leather and should be relatively *flexible*. If it is thought that an innersole is undesirable, correction to the outside of the shoe can be obtained by attaching a wedge to the medial one half of the heel of the shoe. The sole should not be disturbed. The height of the lift can be 1/8, 3/16, or even 1/4 inch in thickness, depending on the size of the child. It is odd that, in dealing with pronation, some confusion exists in regard to whether the lift should be placed on the medial or the lateral side of the heel. In pronation the medial side of the foot is depressed and must be elevated. Therefore, a lift should be applied to the medial side of the heel to elevate the medial side of the foot. If the child is old enough and cooperative enough, exercises which help to strengthen the muscles elevating the long arch can be taught. The exercises commonly taught are designed to strengthen the invertor muscles of the foot and the muscles which increase the height of the longitudinal arch. These exercises include picking up marbles with the toes, standing and rocking the feet into inversion so that the weight is borne on the lateral aspects of the feet, and standing on the lateral aspects of the feet and rising to tiptoe. There are numerous others.

If the complaint has been one of pain either in the feet or in the calves, if the tentative diagnosis is pronation, and if relief has not been obtained by the use of innersoles in the shoes or wedges attached to the heels together with exercises, then the condition should be studied further, on the supposition that the diagnosis may be in error.

In conditions in which the symptoms continue, other problems which highly complicate the situation may be present. Therefore, in addition to the conservative measures just discussed, operative intervention is possible. The Kidner procedure to correct flat foot is used if an accessory scaphoid bone is presumably the underlying fault. In this procedure the accessory scaphoid bone is removed, and the tendon of the tibialis posterior muscle is transplanted so that it underlies the scaphoid bone. The normal support of the longitudinal arch is thereby restored. At times an accessory scaphoid bone is so large that the overlying tissue becomes irritated; that is, the patient's condition is not caused by foot imbalance (pronation), but rather by local pressures on a prominent bony part. Therefore, if pressure cannot be relieved by conservative means, such as the adding of innersoles to shoes, the accessory scaphoid bone is removed, without necessarily using the Kidner procedure.

Various types of arthrodeses can be performed. These include fusion of the scaphoid, medial cuneiform, and the first metatarsal joints, fusion of the scaphoid and the two cuneiform joints, and fusion of the astragaloscaphoid joint. We have been very poorly impressed with the small series of cases we have seen in which arthrodesis has been performed to correct pronation of the foot. (This excepts the Kidner procedure, which is not in the nature of an arthrodesis.) Long and careful consideration should be given to a condition before operative measures of this sort are done.

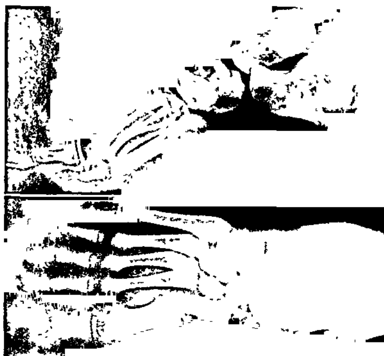
Köhler's Disease (Osteochondritis of the Tarsal Scaphoid)

If the presenting complaint in a child 3 to 6 years of age is pain in the long arch of the foot, the possibility of Köhler's disease should be considered. Köhler's disease is epiphysitis, osteochondritis, or avascular necrosis (whichever term one may wish to use) of the tarsal scaphoid bone. It will be recalled that this disease is, in essence, a condition in which the bone undergoes degeneration for a period of time and later regenerates. (Fig. 25, *A*.) The bone becomes fragmented and, therefore, should be protected from the forces of weight-bearing while in a soft, pliable state. If it is not protected during the malleable state, the tarsal scaphoid bone heals in a deformity which may later result in hypertrophic changes between the talus and scaphoid and the scaphoid and cuneiform bones. Clinically, tenderness occurs directly beneath the long arch in the region of the scaphoid bone. Tenderness may be found likewise medially and on the dorsum overlying the scaphoid. At times a certain amount of swelling is visible.

The suspected diagnosis will be confirmed by roentgenograms. On the roentgenograms, the scaphoid bone may appear to have marked compression of the ossification center. (Fig. 25, *B*.) Conservative treatment consists of the patient's wearing a small boot of plaster and using crutches for several weeks until the tenderness and swelling disappear. An innersole in the shoe to protect the foot in weight-bearing may be used thereafter.

Adduction of the Forefoot

At times the child is brought to the practitioner not because of pain in the feet, but because he trips over his own feet or his feet appear to toe in toward the midline. Examination of the feet usually shows the simple deformity of



A.



B.

Fig 25.—Köhler's disease. *A*, Note fragmentation, especially on the medial aspect of the scaphoid bone. *B*, Note the increased density and apparent compression of the scaphoid bone.

adduction of the forefoot, either unilaterally or bilaterally. (Fig. 26.) The deformity may be more apparent when the child is walking than when he is holding his foot at rest. In this condition it is necessary to counteract the tendency toward adduction by applying a force which abducts the forefoot at each step. The placing of a 3/8 inch lift on the *outer* one half of the sole of the shoe (not including any portion of the heel) will tend to force the foot into abduction at each step. In addition, the parents can be taught to stretch the childs' forefoot into abduction several times a day. The child may also engage in corrective exercises by walking for certain periods of time with the feet held in marked abduction.

If, after a trial of six to eight weeks, improvement is not readily noticed, further diagnostic examination should be made. The possibilities of additional measures of treatment and the possibility that tibial torsion rather than simple adduction of the forefoot is playing the fundamental part in the deformity should be considered.

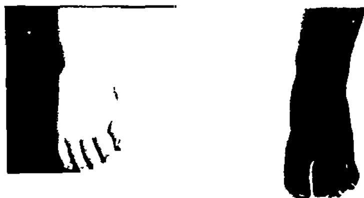


Fig. 26.—Forefoot adduction of the right foot. (From, Larson, C. B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

Medial Torsion of the Tibia

Occasionally a parent brings a child to the practitioner with the complaint that the foot turns in or that the child trips over his own feet. It should be noted that this complaint is quite similar to that which is made in adduction of the forefoot. On examination, however, the foot itself appears to be properly aligned as compared with the ankle. It will be noted, however, that the ankle joint appears to face more medially than is normal when compared with the patella and with the alignment of the entire lower extremity. Therefore, the fault is a deformity of the tibia itself and consists of a medial torsion or rotation on the longitudinal axis of the tibia. The torsion causes the ankle joint to face more medially than is normal, and therefore the foot is held in a position which may cause the child to trip on his own foot or at least to exhibit the deformity of the foot turning in. Correction of this difficulty can be brought about by the use of a 3/16 inch lift placed on the outer one half of the sole of the shoe



A.



B.

Fig. 25.—Kohler's disease. *A*, Note fragmentation, especially on the medial aspect of the scaphoid bone. *B*, Note the increased density and apparent compression of the scaphoid bone

epiphysis appears fragmented. (Fig. 27.) These changes constitute the phase of degeneration. While the epiphysis is in the stage of degeneration, it is pliable and soft and easily deformed. The natural course is that, sooner or later, regeneration follows the degenerative phase. If the epiphysis has been protected from deforming influences while it is undergoing degeneration, there is less likelihood that it will become deformed later.

If a child complains of pain and swelling in the region of the distal metatarsal head, particularly the second metatarsal, it is well to consider that the diagnosis may be Freiberg's infraction. Clinical examination reveals local tenderness directly on the metatarsal head. Movement of the second toe causes pain, and sometimes swelling is sharply localized in this area. The suspicion that the diagnosis is Freiberg's infraction will be confirmed by the roentgeno-



Fig 27.—Freiberg's infraction. Observe the cupping of the second metatarsal head, its expansion, irregularity, and varying density.

grams, which reveal flattening of the head of the second metatarsal, fragmentation of the epiphysis, and areas of irregular density. A diagnosis of "fallen metatarsal arch" in a child should be rarely, if ever, entertained.

Treatment of Freiberg's infraction should afford protection of the soft, pliable metatarsal head during weight-bearing throughout the period of degeneration so that good reconstruction of the epiphysis may take place when regeneration occurs. Protection from weight-bearing can be achieved by the application of a plaster boot and the use of crutches, or an innersole which has a transverse metatarsal bar placed so that the main portion of the weight is borne proximal to the head of the second metatarsal may be placed within the shoe. This innersole should be worn until the tenderness has disappeared and the roentgenograms furnish evidence of good regeneration. If deformity occurs as an end result, in later years hypertrophic changes occur at the second metatarsal head.

(not including any portion of the heel). If correction does not begin shortly, a more radical procedure, such as osteotomy of the tibia and fibula, should be considered, and advice along those lines should be obtained.

Inadequate External Rotation of the Knees

If the complaint is that the child toes in and if the examination has shown that neither adduction of the forefoot nor medial torsion of the tibia exists, then the knees should be examined. Sometimes there is an inadequate range of external rotation within the knee joint itself. With the child sitting on the edge of an examining table and with the knees flexed at 90 degrees, passive motion of the tibia should be carried out to determine the degree to which the tibia can be passively rotated externally. As this is done, the effect of such a maneuver on the position of the foot and ankle (affecting toe-in) is apparent. Occasionally there is no doubt that the toe-in position of the foot occurs because the knee cannot rotate externally enough to allow normal foot placement during gait. Treatment, which consists of placing a 3/16 inch lift on the outer one half of the sole of the shoe (not including any portion of the heel) appears to be of benefit if continued for several months.

Inadequate External Rotation of the Hips

If the complaint is that the child toes in, if the examination has shown neither an adduction deformity of the forefoot nor any medial torsion of the tibia, and if, furthermore, the knees have normal external rotation (see preceding discussion), attention should be directed to the hips. It may be that the passive external rotation of the hip is so much less than normal that the entire lower extremity is held in more internal rotation than normal. Thus in gait the feet are directed medially, and the patient trips over his own feet. The chances for a child to outgrow this deformity by 6 or 7 years of age is excellent. If this does not happen, expert advice should be obtained. It is of importance to remember that there is often a strong hereditary factor in this condition. Therefore, a family history is essential, since the doctor can obtain a prognosis for the patient by discovering the degree of deformity (if any) persisting in the parent.

Freiberg's Infraction (Osteochondritis of the Second Metatarsal Head)

Freiberg's infraction belongs to a group of diseases which affect the epiphyses and whose etiology is not understood. They have been called by various names —epiphysitis, osteochondritis, avascular necrosis, etc. Since these diseases attack different epiphyses, each of the diseases in the group has been named for the man who first described the disease in a particular anatomic location. Thus, if the change occurs in the head of the second metatarsal, the disease is known as Freiberg's infraction. If the disease appears in the tarsal scaphoid, it is shown as Köhler's disease; if in the tibial tuberosity, Osgood-Schlatter's disease; or at the hip, Legg-Perthes' disease. The change in the bone occurs in the following manner Parts of the epiphysis undergo necrosis and therefore appear dense on the roentgenograms. A rich granulation tissue, infiltrated by lymphocytes, invades the epiphysis and replaces portions of the bone. Therefore, on the roentgenograms areas of rarefaction become apparent, and the

site of acute hematogenous osteomyelitis, and it may be that this is the more common or usual method of producing suppurative arthritis.

There are two practical aspects of the situation. First, the diagnosis of either suppurative arthritis or acute hematogenous osteomyelitis should not be by-passed lightly in favor of the diagnosis of rheumatic fever. Irreparable damage to a joint can occur and precious time be lost while the physician is mistakenly treating rheumatic fever when the correct diagnosis is either osteomyelitis or suppurative arthritis (or both). Therefore, do not entertain a diagnosis of rheumatic fever until after suppurative arthritis and acute osteomyelitis have been definitely excluded.

Second, suppurative arthritis (which occurs because of a neighboring osteomyelitis) will not be successfully managed until the acute osteomyelitis is under control.

Acute Hematogenous Osteomyelitis

A child may complain of pain in the lower leg, which might be interpreted as at the ankle or just above the ankle. The child may refuse to walk and frequently may be fretful and irritable. Examination reveals a child who is ill in appearance and whose temperature may be elevated to 102 or 103° F. There may or may not be swelling over the distal tibia above the ankle joint, depending upon how long standing the process is. The area overlying the metaphysis of the distal tibia, that is, the area definitely proximal to the ankle joint and yet distal to the shaft of the tibia, may reveal increased temperature to palpation. The same area reveals tenderness to pressure over the bone. The importance of the symptom of tenderness to pressure over the bone must be adequately emphasized and stressed, since bony tenderness is very suggestive of acute hematogenous osteomyelitis under this set of circumstances. The skillful examiner will find that passive motion of the ankle joint per se can be carried out gently, but with adequate range, to differentiate between acute suppurative arthritis of the ankle joint and acute hematogenous osteomyelitis of the distal tibia.

The history may be one of a break or a cut in the skin or of an upper respiratory infection within one or two weeks prior to the onset of pain in the lower leg. The mechanism is invasion of the blood stream by the etiologic organisms, with a transient or more sustained septicemia. The organisms then lodge in the metaphyseal region of the tibia. At this site the blood is stagnant, and the bone is cancellous and offers a good culture medium for the organism. Essentially, an abscess with destruction of bone then develops. (Fig. 28.) The patient is systemically ill with septicemia, as well as harboring an infection in the bone Management of the condition undertakes to obtain a blood culture, with sensitivity studies carried out upon the etiologic organism. Adequate doses of the proper antibiotic are administered systemically. The leg is rested upon a splint to rest the part, since rest of tissue is one means of combating infection. Intravenous fluids and even transfusions are given, if necessary, as general supportive measures. In children under 2 years of age, the organism is more likely to be *Streptococcus hemolyticus* and next likely, *Staphylococcus*

Suppurative Arthritis of the Ankle

The ankle joint is occasionally the site of acute hematogenous suppurative arthritis. The presenting complaint may be either a limp or a painful, swollen ankle in a child who has an elevated temperature and is obviously sick. Ordinarily there will have been an initial infection somewhere in the body caused by a break in the skin, an upper respiratory infection, etc. There follows a transient, or more sustained septicemia, and the etiologic organism is deposited in the synovium or synovial fluid of the joint. On examination the child generally will appear flushed, sick, and irritable and, at times, will even be prostrate. He may refuse to use the ankle, even refusing to walk. The affected ankle will usually be swollen, hot to palpation, and very painful on even gentle passive motion. The temperature may be elevated to 102 or 103° F. In the management of suppurative arthritis of the ankle in a child, blood cultures should be done and sensitivity tests carried out to determine the causative organism. Aspiration of suppurative material from the ankle can be done as a diagnostic procedure. The material should be cultured, smeared, and stained. Adequate doses of the proper antibiotic, systemically administered, should be instituted immediately. The general condition of the patient should be protected by adequate intravenous fluids, and supportive therapy should be carried out, even to blood transfusions if the general condition appears to warrant it. It is well to place the affected extremity at rest on a splint so arranged that frequent observation of the ankle can be carried out. If the swelling and redness of the ankle do not shortly subside and the temperature does not fall (within two to three days), surgical incision and drainage of the ankle joint should be performed. The etiologic organism is usually *Staphylococcus aureus* or *Streptococcus hemolyticus*, but at times pneumococcus and typhoid bacillus are also found. In the differential diagnosis of a painful swollen ankle in a child with an elevated temperature, acute hematogenous osteomyelitis, rheumatic fever, rheumatoid arthritis, meningococcal synovitis, and tuberculosis should be considered. A blood culture and a culture of the aspirated material from the ankle joint are the best means of identifying the etiologic agent and of dealing with the differential diagnosis. Roentgenograms in the early stages (that is, from seven to ten days) are likely to be negative. Meningococci are very difficult to grow by culture from joint fluid, and diagnosis of meningococcal synovitis depends upon the history of recent meningococcal meningitis or of septicemia-like disease with hemmorrhagic skin lesions. The fluid of rheumatoid arthritis and rheumatic fever will not produce organisms on culture. Electrocardiograms of patients with rheumatic fever will ordinarily reveal abnormalities Patients with rheumatoid arthritis should show the typical fusiform swelling of the proximal interphalangeal joints of the hands. Tuberculosis can be distinguished by positive skin tests and roentgenograms showing destruction of the nonweight-bearing portions of the bone.

We have dealt with acute suppurative arthritis of the ankle as though it were a primary condition occurring alone Perhaps under certain circumstances this is true. It should be kept in mind, however, that a septic joint frequently arises because the neighboring bone (in our case, the distal tibia) has become the

have been excluded. Clinical and electrocardiographic examination may aid in the differential diagnosis. Treatment of rheumatic fever is beyond the scope of this book. The condition is mentioned only because it is a consideration in differential diagnosis.

Rheumatoid Arthritis

As is true in rheumatic fever, rheumatoid arthritis should be considered only after suppurative arthritis and acute hematogenous osteomyelitis have been excluded as likely diagnoses in a child who complains of a painful, swollen ankle and has an elevated temperature. Painful fusiform-shaped proximal interphalangeal joints should lead the practitioner to make the correct diagnosis of rheumatoid arthritis. A fuller discussion of rheumatoid arthritis and its treatment are found in Chapter Twelve, Arthritis (page 366). The condition is mentioned here only because it is a consideration in differential diagnosis.

Tuberculous Arthritis

The ankle joint like any other major joint in the body, is susceptible to infection by the tubercle bacillus. The complaint is ordinarily a painful, swollen ankle, which is relatively long standing and of mild intensity. There may be associated complaints of weight loss, general lassitude, and loss of appetite. Examination reveals a swelling around the ankle joint which is indolent in character and neither hot nor particularly tender. Motion of the ankle is, of course, painful. Diagnosis can be made upon the basis of the x-ray pictures. One of the first signs which appears on the x-ray pictures is atrophy of the bone. The first sign of destruction occurs at the nonweight-bearing portions of the ankle joint. Later, more extensive destruction is seen. Diagnosis is aided by positive skin tests and by the presence of stigmas of tuberculosis elsewhere in the body, particularly in the lungs. It is possible to obtain aspirate from the ankle joint and have it cultured for tubercle bacilli and inoculated into a guinea pig. Conservative treatment consists of the application of a plaster boot to place the foot and ankle at complete rest. The position of the foot at the ankle should be that of optimal function. Medication in the form of streptomycin combined with para-aminosalicylic acid (PAS) can be given. Furthermore, the patient should be treated systemically with the same general measures used for tuberculosis elsewhere in the body; namely, with complete rest and a high caloric, nutritious diet having a high vitamin content. A search for tuberculous processes in other parts of the body should be made. It is well to keep in mind that tuberculous arthritis must be secondary, by its nature, to infection elsewhere, particularly pulmonary or genitourinary. Prognosis depends more upon the extent and severity of the primary tuberculous disease than upon the tuberculous process in the ankle. If, in spite of conservative treatment with plaster casts for many weeks, the process appears to be progressing to further destruction, operative eradication should be considered.

Calcaneal Apophysitis

The presenting complaint for calcaneal apophysitis is usually pain in the heel. Sometimes the patient walks on tiptoe without specifically complaining

aureus, with a small percentage being pneumococci or typhoid bacilli. At this age the bone is soft and easily destroyed. Therefore, soft tissue abscesses are frequently present. They may be aspirated and the cavity filled with penicillin in solution, or a presenting abscess may simply be incised and drained. The bone tends to heal readily in these infants.

In children over 2 years of age, *Staphylococcus aureus* is the most likely etiologic agent. Usually with adequate doses of the proper antibiotic (that to which the actual infecting organism is most sensitive as determined by laboratory tests), the process of acute hematogenous osteomyelitis can be controlled without surgery, and the afteraffects of chronic osteomyelitis can be avoided.



Fig. 28 —Acute hematogenous osteomyelitis of the tibia

At times surgical bone decompression is necessary in these older children, since the bone is not so easily destroyed nor so easily reconstructed once it is infected, as it is in infancy. Reference should be made to the discussion on Suppurative Arthritis of the Ankle for the conditions to be distinguished in differential diagnosis.

Rheumatic Fever

If a child has an elevated temperature and complains of pain and swelling around the ankle, the doctor may *safely* consider rheumatic fever as a likely diagnosis *only if* suppurative arthritis and acute hematogenous osteomyelitis

bursae are inflamed by rubbing due to the hard heel counter of the shoe, the condition should be distinguished from the calcific bursitis which is common around the shoulder. As a rule, no calcific deposit is found in Achilles tendon bursitis. Treatment of a conservative nature is usually successful. The application of an ice bag to the heel aids in relieving pain. The heel counter of the shoe should be removed by a cobbler so that this area of the shoe is soft and does not rub on the Achilles tendon. The patient can be advised to wear sneakers or tennis shoes for a period of time to allow the bursitis to subside. Furthermore, a felt pad can be placed in the shoe to elevate the patient's heel sufficiently so that the shoe does not strike harshly at the region of the Achilles tendon and the os calcis. Ordinarily, two weeks of wearing a shoe with a soft portion overlying the inflamed area is sufficient for recovery.

Post-Poliomyelitic Deformities of the Foot and the Ankle

If physical therapy in the form of stretching and active exercises has failed to remedy post-poliomyelitic deformities of the foot and ankle (and deformities in general), the conservative therapy consists of applying the proper brace to support the affected part. The radical therapy, which should be undertaken by a physician of experience in this field, includes arthrodesis to stabilize the flail joint, tendon transference to allocate muscle power to the area needing it, a combination of arthrodesis and tendon transference, tendon lengthening, capsulotomy, and fasciotomy.

As an aftermath of anterior poliomyelitis, several different types of deformities of the foot and ankle with varying degrees of severity are found. The patient's general complaint is a weak foot, foot drop, or, at times, deformity of the foot. Only a few of the most common deformities together with some indication for therapy, will be considered here. In the following discussion it is assumed that exercises and physical therapy were carried out but failed to remedy the condition.

Flail Foot.—In patients with flail foot very little muscle power exists in any of the muscle groups controlling the foot and ankle, whether in dorsiflexion, plantar flexion, inversion, or eversion. In this condition it is necessary to stabilize the foot on the leg at the ankle, both in a lateral plane and an anteroposterior plane A conservative procedure is to apply a molded leather cuff, with metal re-enforcements, over the foot and ankle. This cuff may be worn inside the shoe, which itself is braced with bilateral calipers from the heel on up the leg to any desired height. The radical procedure under such circumstances is to perform a panastragalar arthrodesis. Arthrodesis is that surgical procedure whereby a joint is purposely destroyed and caused to undergo bony ankylosis. The purpose of arthrodesis is to produce a stable and painless (although immovable) region in a joint where motion is undesirable Motion at a given joint may be undesirable for several reasons. The joint may be painful, weak or flail, and therefore it is useless as an articulation. The joint may be functionless because it is the site of deformity. Arthrodesis is usually performed by cutting away the articular surfaces of the joint and approximating the raw bony surfaces until healing has taken place, as in the case of a fresh fracture. However, it is

of the heel. The practitioner should be aware of this possibility and look for signs of apophysitis. Apophysis is the name given to any epiphysis on which a tendon has become inserted. The disease process, namely, epiphysitis, also occurs in the calcaneal apophysis. This apophysis is situated on the posterior aspect of the calcaneous, and it is there that the Achilles tendon inserts. The patient is usually 9 to 15 years of age. Tenderness to pressure, either directly over the posterior aspect of the heel or over the sides of the heel where the epiphyseal cartilaginous plate is located, exists. It may be observed that the child is walking on tiptoe rather than bearing weight on the posterior aspect of his foot and heel. The roentgenograms will confirm the suspicion of calcaneal apophysitis. They reveal a very dense-appearing calcaneal apophysis, with or without fragmentation. It must be remembered, however, that normally the calcaneal apophysis is often dense and somewhat fragmented in appearance. This increases the difficulty of diagnosis by roentgenograms.

Certain features common to epiphysitis should be evident. The first feature common to avascular necrosis in this disease entity is that the epiphysis is attacked. Second, the disease occurs in a given epiphysis at the time it is most active in growth. Third, the process is, by its nature, a disturbance of childhood. Fourth, there is a degenerative and regenerative phase whose changes as shown by the roentgenograms are similar, whether the process is found in the calcaneal apophysis or in the head of the second metatarsal. It should be remembered that many epiphyses in the body may be affected, but that only the most common ones in the foot have been described under the discussions of Freiberg's infraction, Köhler's disease, and calcaneal apophysitis.

Treatment of calcaneal apophysitis is symptomatic and conservative. A lift inside of the shoe, which places the foot in equinus and releases the tension of the Achilles tendon, relieves pain, and is adequate treatment. Differential diagnosis should be made between calcaneal apophysitis and bursitis of the Achilles tendon.

Achilles Tendon Bursitis

A child may be brought to the practitioner with the complaint of a painful heel. The doctor should first establish that the child does not have calcaneal apophysitis, as just described. If the roentgenograms show negative findings for avascular necrosis of the calcaneal apophysis, the physician should entertain the diagnosis of Achilles tendon bursitis. On examination the skin overlying the Achilles tendon at the junction with the os calcis may be thickened, raised, and red and inflamed in appearance. Tenderness directly at the insertion of the Achilles tendon into the os calcis is commonly present. It is also frequently noted that the heel counter of the shoe is hard and consequently rubs the junction of the Achilles tendon and the os calcis. The patient may recently have obtained a new pair of shoes.

It is well to keep in mind that pressure, with rubbing, over a bony prominence can develop a bursa between the skin and the bony prominence. Around the Achilles tendon the formation of such a bursa is called adventitious since several different bursae can be formed by chance in this location. When the

imbalance. In the condition of post-poliomyelitic foot drop, the peroneal tendon on the lateral aspect of the foot can be severed from its attachment and redirected to the area of the insertion of the weakened tibialis anterior. There are several drawbacks to tendon transference as a definitive procedure. First, the transferred muscle system is usually not adequate in power to make up entirely the deficiency for which the transference was performed. Second, the patient has to be trained to use the muscle group (sometimes an antagonistic one) to do the work of the weakened or paralyzed muscle or muscle group. Third, as time proceeds, the newly transferred muscle tendon system sometimes becomes overstretched and therefore loses the power anticipated from it, with a consequent gradual worsening of function. Because of these difficulties, it is common practice to perform various types of arthrodesis and to combine the arthrodesis with tendon transference. In this way, correction of the deformity by remodeling the bone and joints can be carried out, as well as obtaining the stability attendant upon arthrodesis. Furthermore, a desired increase in the muscle power sought for the area can be obtained. Therefore, in treatment of post-poliomyelitic foot drop, it is possible to perform a triple arthrodesis (in which the subastragalar, the calcaneocuboid, and the taloscaphoid joints are all fused) and to transfer the peroneus longus tendon to the area of the tibialis anterior insertion on the scaphoid.

Calcaneus Deformity.—Upon occasion, weakness of the gastrocnemius, which is responsible for a type of calcaneus deformity, is found. This condition is less common than the foot-drop disability just described. The patient walks with a flat-footed gait, because he is unable to spring up onto tiptoe during the normal phases of the gait. Conservative therapy consists of the use of a brace of the spring type which is the reverse of that used in the foot-drop brace and is constructed so that the patient will be aided in the attempts to rise up on tiptoe. This type of deformity is frequently progressive, and therefore operation is commonly employed.

Equinovarus Deformity.—At times, deformities of the foot may be due to tightening of the Achilles tendon so that the foot is kept in equinus and cannot be brought into dorsiflexion, either by the patient's own muscle activity or by attempts of the examiner through passive stretching. As an additional disability to that of a tight Achilles tendon, the plantar fascia is sometimes contracted so that the foot is held in a position of talipes equinovarus similar to that in congenital clubfoot. In this condition it is assumed that the conservative therapy of stretching by a physical therapist has failed to provide solution. Under such circumstances, surgical intervention is recommended.

It is possible to expose the Achilles tendon surgically and, by any one of several different plastic procedures, to lengthen the tendon so that normal dorsiflexion can be carried out. It is well to keep in mind that the tendon is not the only soft tissue structure around any given joint, and whereas any contraction of the tendon can be lengthened, an operative attack on the capsule of the joint itself may also be necessary. For example, in an equinus deformity of the foot at the ankle, lengthening of the Achilles tendon may not be sufficient to allow normal passive dorsiflexion of the foot. Therefore, the operator should proceed

also possible to fuse the joint by placing the bone graft across the previous joint space after excising the articular cartilage. This is known as intra-articular fusion. Extra-articular fusion is the placing of the bone graft from one bony prominence to another, by-passing the joint. It should be obvious that when an arthrodesis is performed, the limb should be placed in the position of optimum function. It should be pointed out that if a fusion in the treatment of a child is contemplated, the physician must take into consideration the child's age because of the amount of cartilage present in the child's foot and ankle. If the child is much younger than 11 years of age, he has so much cartilage in proportion to bone in the foot and ankle that fusion or arthrodesis may fail. Therefore, preferably, panastragalar arthrodesis should not be undertaken until the child is 12 to 13 years of age In this specific procedure, the talus is fused to the tibia at the ankle and then to the scaphoid. The subastragalar joints between the calcaneous and the talus are fused, and the joint between the calcaneus and the cuboid is fused. Therefore, in general, when treating a child with a flail foot, conservative therapy, using a leather cuff with metal re-enforcements and a leg brace to aid in walking and to prevent contractural deformities until the patient is old enough for panastragalar arthrodesis, is best.

Drop Foot.—Another common post-poliomyelitic disability of the foot and ankle is that of weakness in dorsiflexion of the foot. Frequently, examination of the patient will reveal that he walks with a steppage-type gait, that is, he elevates the knee in a high and exaggerated manner to clear the drop foot from the floor and then flaps the foot rather awkwardly on the floor in front of him during gait. The patient may or may not be able to go up on tiptoe during the take-off phase of the step. Further examination reveals that the patient is unable to dorsiflex the foot at all, or can do so only weakly, and is unable to do so against the resistance of the examiner Weakness of the tibialis anterior muscle, which is the strongest muscle of dorsiflexion in the foot, is a very common residual of anterior poliomyelitis. In association with this weakness it is also found that the Achilles tendon is probably not contracted and not tight. However, if the Achilles tendon is contracted and is contributing to the deformity, it can be treated as a separate condition from the main one of weakness in dorsiflexion of the foot The conservative therapy used for foot drop of this type, which incidentally assumes that the foot is reasonably stable in the lateral plane, can be carried out by the use of a foot-drop brace. In the main, a brace is applied which, because of a lock at the ankle joint, will prevent the foot from dropping beyond 90 degrees during gait. Another possible type of brace is one which is made with a spring to pick the foot up and place it in a dorsiflexed position during gait. If the condition cannot be helped by the use of the various types of foot-drop braces, operative means can be employed.

Tendon transference, tendon transference plus arthrodesis, or arthrodesis alone can be used in the more radical treatment. In the procedure of tendon transference, a muscle tendon group, acting as a motor system, is transferred from its normal position in an area which needs less power to an area needing additional power. In addition to adding increased power to a given area, tendon transference also corrects a deformity which is due to already existing muscle

position. If braces are used, they can be designed to serve not only as a support, but also as a correcting influence on the deformity; that is, the braces exert a pressure applied medially at the lateral aspect of the knees. A warning should be issued not to keep braces on too long without seeking experienced advice, since knee joint stiffness can occur with disabling results.

Whether lifts are used on the shoes or braces applied to the legs, the family doctor should realize that several months of treatment are necessary to achieve correction of the deformity by either means.

It should be kept in mind that operative correction of congenital bowlegs is possible, if conservative measures are unsuccessful.

Rachitic Bowlegs.—Although genu varum is usually congenital, even today rickets is occasionally the etiologic factor. (*Fig. 29.*) The usual clinical and roentgenologic signs constitute the diagnosis. Antirachitic therapy alone is usually successful in correcting the deformity, without the need for lifts on the



Fig. 29.—Bowlegs (genu varum), which are the result of active rickets If the rickets is brought under control, the bowlegs will correct themselves by further growth. (From Larson, C B , and Gould, M : Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co)

shoes, braces on the legs, or operations. If antirachitic therapy fails in a patient who otherwise apparently has rickets, the strong possibility that the underlying difficulty is renal rickets should be considered

Tibia Vara (Blount's Disease).—Genu varum in the strict sense of the word refers, of course, primarily to a deformity of the knee joint, and the tibial and femoral shafts can be presumed to be relatively normal. Hence the deformity could arise through a disturbance of epiphyseal growth. In a condition described by Blount, the medial one half of the proximal tibial epiphysis undergoes a change, probably in the nature of osteochondritis, such as Legg-Perthes' disease of the hip. As a result of the collapse, deformity, and disturbance of the growth of the epiphysis at this particular location (Fig. 30, *A* and *B*), the lower leg is swung medially toward the midline so that genu varum, or bowlegs, results. There is

to the ankle joint capsule and sever it as well. This procedure is known as posterior capsulotomy. Furthermore, the contracture of the plantar fascia should be dealt with in the same manner. The procedure of fasciotomy is simply that of cutting through and releasing a fascial band. It is usually necessary to expose the plantar fascia on the medial aspect of the foot at its insertion into the os calcis and to sever it from the os calcis in order to correct passively the adduction deformity which the plantar fascia, by its contracture, has produced.

DISTURBANCES OF THE KNEE IN INFANCY AND CHILDHOOD

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	(a) Congenital bowlegs	56
	(b) Rachitic bowlegs	57
	(c) Tibia vara (Blount's disease)	57
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Walks with knees bent	(1) Spastic flexion of knee (cerebral palsy)	61
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	(6) Acute hematogenous osteomyelitis of tibia or femur.	64
Painful swollen knee without elevated temperature	(1) Tuberculous synovitis or arthritis of knee	65

Bowlegs (Genu Varum)

Bowlegs (genu varum) is not uncommon in children. The deformity can have as its basis congenital factors, rachitic factors, or epiphyseal disturbances.

Congenital Bowlegs.—The common condition is bowing of the legs due to congenital causes, with the bowing in the shaft of either the tibia or femur or both. To correct this difficulty, braces for the legs or lifts in the shoes may be used. If lifts are used, they should be applied to the *outer* one half of the sole and heel of the shoes and should be approximately $\frac{3}{16}$ to $\frac{1}{4}$ inch in height. The purpose of the lift is to provide a constant adducting force upon the legs at the knees. Thus, as the child grows, the legs will tend to swing into a more normal

sition. If braces are used, they can be designed to serve not only as a support, t also as a correcting influence on the deformity; that is, the braces exert a ssure applied medially at the lateral aspect of the knees. A warning should issued not to keep braces on too long without seeking experienced advice, ice knee joint stiffness can occur with disabling results.

Whether lifts are used on the shoes or braces applied to the legs, the family ctor should realize that several months of treatment are necessary to achieve rrection of the deformity by either means.

It should be kept in mind that operative correction of congenital bowlegs possible, if conservative measures are unsuccessful.

Rachitic Bowlegs.—Although genu varum is usually congenital, even to-ly rickets is occasionally the etiologic factor. (Fig. 29.) The usual clinical ıd roentgenologic signs constitute the diagnosis. Antirachitic therapy alone is ually successful in correcting the deformity, without the need for lifts on the



Fig. 29.—Bowlegs (genu varum), which are the result of active rickets. If the rickets is brought under control, the bowlegs will correct themselves by further growth. (From Larson, C B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

shoes, braces on the legs, or operations. If antirachitic therapy fails in a patient who otherwise apparently has rickets, the strong possibility that the underlying difficulty is renal rickets should be considered.

Tibia Vara (Blount's Disease).—Genu varum in the strict sense of the word refers, of course, primarily to a deformity of the knee joint, and the tibial and femoral shafts can be presumed to be relatively normal. Hence the deformity could arise through a disturbance of epiphyseal growth. In a condition described by Blount, the medial one half of the proximal tibial epiphysis undergoes a change, probably in the nature of osteochondritis, such as Legg-Perthes' disease of the hip. As a result of the collapse, deformity, and disturbance of the growth of the epiphysis at this particular location (Fig. 30, *A* and *B*), the lower leg is swung medially toward the midline so that genu varum, or bowlegs, results. There is

also an associated (but milder) anteromedial bow of the tibia. Tibia vara of this type is not encountered as commonly as the congenital type. It is more difficult to correct the epiphyseal variety (and to maintain the correction), since the deformity tends to recur until healing of the fundamental disease occurs. The prognosis in general is poorer in Blount's tibia vara than in congenital bow-

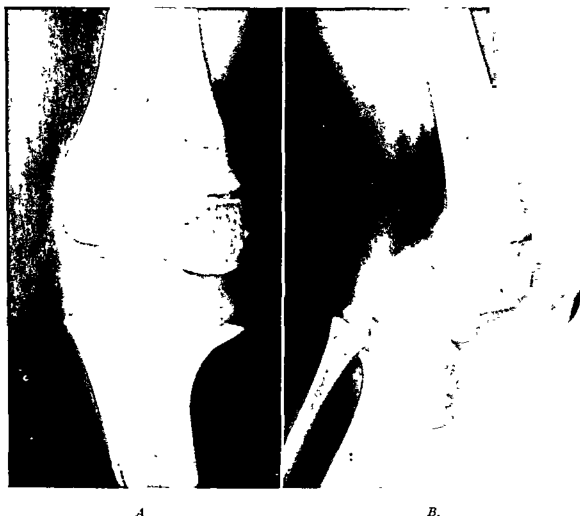


Fig 30.—Blount's disease. *A*, Anteroposterior view. Note the varus deformity and the failure of growth at the medial one half of the epiphyseal line. *B*, Lateral view of the same patient shown in *A*.

legs. However, surgical correction by osteotomy and bone grafting can be performed, even though it may be necessary to repeat the procedure before correction is eventually maintained.

Knock-Knees (Genu Valgum)

Knock-knees (genu valgum) is a deformity in which the lower leg passes laterally *from the normal line of the extremity, and the deformity* appears to start at the knee joint. It can usually be overcome by the use of proper lifts and leg braces *in children* The braces which are used in this condition exert an

outward pull on the medial aspect of the knee. If lifts on the shoes are used in treatment of knock-knee, they should be placed on the *medial* aspect of the heels and soles and should be approximately 3/16 to 1/4 inch in height. The ordinary condition of knock-knee is usually congenital or developmental in nature. In a child 2 to 3 years of age there is adequate time for the growth potential to correct the deformity.

In summary, then, the ordinary case presented to the practitioner will be bilateral and congenital or developmental in nature and will be seen at a very early age. Correction can ordinarily be accomplished by conservative therapy, with lifts applied to the medial one half of the soles and heels of the shoes or proper braces applied to the legs. Both methods will require several months of treatment (six to eight) for correction of the deformity. Operative correction is possible if conservative therapy fails. A warning should be issued that stiffness of the knees, with resultant disability, can occur if braces are used for too long a period. Therefore, consultation should be obtained if correction is not progressing satisfactorily.

Osgood-Schlatter's Disease (Osteochondritis of the Tibial Tuberosity)

In children 10 to 14 years of age, pain and swelling around the knee are not infrequently encountered. It is of note that the parents are alarmed by a peculiar, persistent, and progressive swelling which they believe to be in front of and just below the knee, while the child is more disturbed by the pain he experiences upon descending stairs or squatting than he is by the swelling. Examination reveals that the region of the tibial tuberosity just below the knee joint level and located, of course, anteriorly may be quite swollen, even boggy to palpation, and tender to the touch. Extension of the knee against resistance is quite painful and at times may be impossible. Examination reveals that pain is elicited by various activities, such as stooping, squatting, or kneeling. It is clear that any activity causing a strain on the attachment of the quadriceps tendon to the tibial tuberosity will cause pain. Roentgenograms reveal soft tissue swelling overlying the tibial tuberosity (which at this age is an epiphysis) and fragmentation of the ossification center of the tibial tuberosity. (Fig. 31.) Thus, the process which is responsible for the complaint of swelling and pain at the tibial tuberosity is, in fact, avascular necrosis or osteochondritis of the epiphyseal center of the tibial tuberosity. It is probable that Osgood-Schlatter's disease is essentially the same as the process known as Kohler's disease of the foot, Legg-Perthes' disease of the hip, or Freiberg's infraction of the second metatarsal head. In common with avascular necrosis of an epiphysis anywhere in the body, Osgood-Schlatter's disease undergoes its phase of degeneration and its phase of regeneration. The process may be bilateral, first occurring in one knee and then later in the other. Conservative therapy is usually successful in relieving the pain and disability. It is well to advise the parents, however, that the process will leave an enlarged and irregular tibial tuberosity, even after healing has taken place. The conservative therapy aims at relieving stress at the area of the tibial tuberosity. Such an end can be achieved by solid support to the knee. This support can be a thick bandage comprised of sheet wadding and Ace Band-

ages, or, more efficiently, a plaster cylinder for the knee. In applying the plaster cylinder to the knee, the skin is painted with tincture of benzoin and two strips of adhesive, one on each side of the knee, are applied so that part of the adhesive is incorporated into the plaster cast to prevent the cast from dropping down after it has been applied. A plaster cylinder for the knee allows weight-bearing, and at the same time prevents flexion of the knee and severe stress on the tibial tuberosity. The length of time for immobilization by a plaster cylinder should be four to six weeks. If, for some reason, conservative therapy is undesirable, multiple drilling of the epiphysis by operative means is possible, but the disease is ordinarily self-limiting and therefore operation is ordinarily unnecessary.

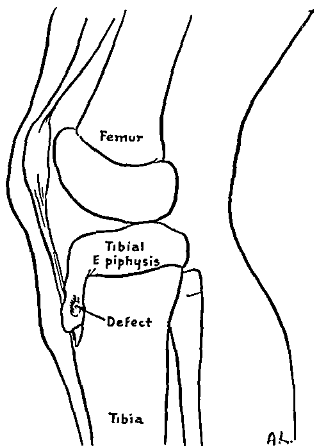


Fig 31 —Osgood-Schlatter's disease Epiphysitis of the tibial tubercle (From Larson, C. B., and Gould, M Calderwood's Orthopedic Nursing, 1957, The C V Mosby Co)

Post-Poliomyelitic Weakness (Genu Recurvatum)

A child who walks with the knee thrown backward should arouse the immediate suspicion of being a victim of anterior poliomyelitis. Because of muscle weakness, the patient attempts to lock the knee during gait by hyperextending it. Therefore, he gains stability of the knee by depending upon the capsule and ligaments rather than upon his weakened muscles. Unfortunately, such a practice gradually stretches the capsule so that a progressive deformity of recurvatum or "back knee" is likely to ensue Examination reveals that the knee

can be brought into hyperextension passively; that is, the tibia can be pointed more anteriorly upon the femur than is possible with the normal knee. If the deformity of genu recurvatum is incipient, it can be controlled by the application of a brace, which is, essentially, a knee cage which locks so that extension beyond normal position cannot occur. Long leg braces attached to the shoe, extended up the thigh (but not so far as the hip), and locked to prevent extension beyond the normal range of the tibia on the femur can be used. Furthermore, it is possible to perform operative procedures, such as a bone block, which can prevent hyperextension of the knee. If such procedures seem indicated, the doctor should obtain the opinion of an especially experienced consultant.

Spastic Flexion of the Knee (Cerebral Palsy)

Ordinarily a patient with cerebral palsy who exhibits spastic flexion of the knee is brought to the doctor with a complaint which more generally pertains

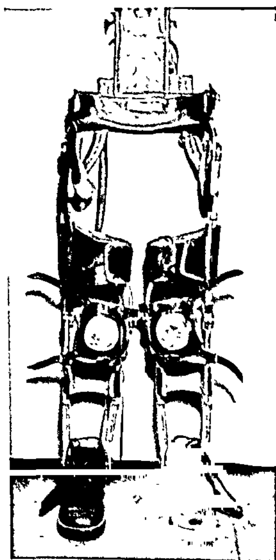


Fig. 32.—Long leg braces with pelvic girdle worn by cerebral palsy patient to prevent flexion contractures and to increase stability. (From Larson, C. B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

to brain injury than to the specific complaint of walking with a flexed knee. However, the complaint of flexed knee should lead the physician to make a sufficient examination to discover a condition of spastic paralysis, either localized in one extremity or involving many other parts of the body as well. Examination of the knee will reveal that extension of the knee is impossible, passively or actively. The physician is able to palpate the dynamic force of the overpowerful knee flexors in his attempt at extension of the knee. It is also most likely that examination will show the foot to be in spastic equinus as well, and it is furthermore very likely that the physician will find that the patient walks with a scissors gait due to spasticity of the adductor muscles of the thigh. (See Fig. 24.)

Treatment of the entire problem of spastic paralysis should be carried out along lines indicated in the discussion on Cerebral Palsy (page 111). However, local treatment of the knee can be performed along either conservative or radical lines The parents can be taught to stretch the spastic knee repeatedly at exercise periods during the day. Plaster splints, extending from well up the thigh down to and including the foot, with as much extension of the knee as possible, can be used for night splints. Braces, which are designed to achieve increasing degrees of extension of the knee, are also available and can be used during the child's sleeping periods After the deformity has been sufficiently well corrected, it is possible to apply long leg braces (Fig. 32) to afford a better gait. The joints of the brace at the hips and knees can be locked at periods of rest so that they exert a continuous correcting force. If conservative methods are unsuccessful, operative methods are possible. There are three general operative procedures First, the tibial tuberosity and its attached extensor apparatus can be advanced more distally down the tibia to increase its mechanical advantage and relative power. Second, the hamstring tendons can be lengthened both medially and laterally, with or without posterior capsulotomy of the joint or transplant of the hamstrings into the femur. Third, neurectomy, in which motor branches to the hamstring muscles are selectively severed, can be performed. Operative procedures should not be carried out unless the physician is especially experienced in the surgery of spastic paralysis, since many surprising and disappointing results occur in surgery for this condition.

Acute Hematogenous Suppurative Arthritis

A child may complain of a painful, swollen knee, appear sick, and have an elevated temperature Under such circumatances, the physician should consider most strongly the possibility of acute hematogenous suppurative arthritis. Examination will reveal a very sick child, with a temperature of 102 to 103° F., who may be dehydrated, who has been vomiting, and who is restless and irritable. Examination of the knee will reveal that the knee is markedly swollen, and the suprapatella pouch of the knee which surrounds and extends above the patella will be tense, swollen, and tender. Even gentle passive motion of the knee may be impossible without a great deal of pain for the patient, and he may be unable to move the knee actively at all because of the severity of the pain. X-ray pictures commonly reveal nothing except a cloudiness in the region of

the suprapatella pouch. The cloudiness is interpreted by the roentgenologist as an effusion of the joint. A blood culture, with sensitivity studies, may be taken, and the fluid of the knee may be aspirated and sent for culture, sensitivity studies, and smears. Positive results from the aspiration of the knee fluid is, of course, conclusive evidence of suppurative arthritis. The organism anticipated is most commonly *Staphylococcus aureus*, but sometimes it is streptococcus, and less commonly, pneumococcus, meningococcus, or typhoid. The condition arises because the patient has developed septicemia, and the organisms have lodged in the synovium of the joint and/or the distal femoral metaphysis.

Treatment is along two general lines, the systemic and the local. In systemic treatment the patient should receive adequate doses of the proper antibiotic to control the septicemic phase. He should also receive adequate intravenous fluids and even blood transfusions if his condition warrants it. Medication for pain is of course indicated, according to the judgment of the physician. The local management of the knee joint consists first of placing the part at rest, either on a metal or plaster splint, to diminish pain and allow the tissue to combat infection. Next, the knee joint may be aspirated of the purulent material, and penicillin may be injected following repeated washings of the joint with sterile saline solution. It should be emphasized that the aspiration and irrigation of the knee, by means of an aspirating needle and the instillation of penicillin, should be carried out under the strictest aseptic precautions. If it is apparent within two or three days at the most that the infection of the knee is not subsiding satisfactorily, incision and drainage of the knee should be carried out operatively. Regardless of whether the treatment by antibiotics systemically and multiple irrigation of the joint locally or the operative measure of incision and drainage surgically has been necessary, the aftertreatment is important. This consists of physical therapy, aimed at increasing joint range by active assistive motions and by muscle-building exercises. The condition of hematogenous suppurative arthritis of the knee should be distinguished, of course, from the painful, swollen knee, accompanied by elevated temperature, occurring in patients with rheumatic fever, rheumatoid arthritis, meningococcal arthritis, and tuberculosis.

Rheumatic Fever

Rheumatic fever may be distinguished by the fact that the joint fluid does not show organisms on culture. The history usually is one of migratory joint pain involving several different joints in the body, and there are cardiac findings, either upon clinical or electrocardigraphic examination. Keeping in mind that a joint can be rapidly destroyed by suppuration and that time is precious, it should be presumed that a painful, swollen knee is suppurative arthritis, and the diagnosis of rheumatic fever should not be entertained until it has been proved that the joint is not septic.

Meningococcal Arthritis

The swollen joint associated with meningococcal arthritis ordinarily shows no growth on culture of the aspirated fluid, since the meningococcus is very

to brain injury than to the specific complaint of walking with a flexed knee. However, the complaint of flexed knee should lead the physician to make a sufficient examination to discover a condition of spastic paralysis, either localized in one extremity or involving many other parts of the body as well. Examination of the knee will reveal that extension of the knee is impossible, passively or actively. The physician is able to palpate the dynamic force of the overpowerful knee flexors in his attempt at extension of the knee. It is also most likely that examination will show the foot to be in spastic equinus as well, and it is furthermore very likely that the physician will find that the patient walks with a scissors gait due to spasticity of the adductor muscles of the thigh. (See Fig. 24.)

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is sweating, restless, irritable, and flushed and has a temperature of 102 to 103° F. Local examination of the area surrounding the knee will reveal acute, sharply localized tenderness over the bone, whether it be the metaphysis of the tibia or the femur. Emphasis should be placed upon the sign of acute bone tenderness, since when it is present it strongly suggests a diagnosis of acute hematogenous osteomyelitis. Gentle examination of the knee will reveal that the knee joint per se can be moved passively by a skillful examiner without undue pain to the patient. This is in direct contrast to the situation in acute hematogenous suppurative arthritis of the knee. Furthermore, the knee joint per se is not ordinarily swollen, unless per chance it also has been secondarily invaded by the infective agent and is, in fact, the site of a suppurative arthritis as well.

Treatment consists of obtaining a blood culture with sensitivity tests, administering intravenous fluids or blood transfusions, and administering the proper antibiotics systemically in adequate doses. A local treatment consists of immobilizing the part to rest the extremity and to allow the natural resistance of the tissue to perform at its greatest efficiency. The part is put to rest on either a plaster splint or a metal splint, and the area is observed for any appearance of fluctuant masses. If, by lysis, the temperature does not return to normal within the next two or three days, operative intervention should be considered. Operative intervention in this instance consists of exposing the metaphysis of the bone and excising a window of cortex in the metaphysis to drain the infected cancellous portion. If subcutaneous fluctuant areas develop, they may be handled in one of two ways—either by aspiration of the material through a needle and the instillation of an antibiotic locally or by incision and drainage of the fluctuant area. After the acute phase of the acute hematogenous osteomyelitis has subsided, physical therapy, using graded active resistive exercises, should be undertaken to regain motion in the knee joint and power in the surrounding muscles.

The main complication of acute hematogenous osteomyelitis of either the tibia or the femur, excluding suppuration of the knee, is the development of chronic osteomyelitis. This process may be responsible for recurrent sinus formation, with multiple abscesses which gather and burst, drain their purulent material, and undergo temporary healing. In chronic osteomyelitis smaller or larger sequestra of bone may be formed, and some pieces may be extruded spontaneously, whereas others can be extruded only by operative help. Chronic osteomyelitis may be indirectly responsible for the shortening or lengthening of the entire extremity, since the process may inhibit growth in neighboring epiphyses, or it may increase the blood supply to the entire extremity and thereby increase the length of the extremity. Chronic osteomyelitis may also be responsible for loss of motion of the neighboring joints, in addition to the recurrent painful sinus formation just described. It is a mistake to apply casts and keep them on for prolonged periods of time, since loss of joint motion will result.

Tuberculous Synovitis or Arthritis of the Knee

A child is sometimes brought to the family doctor with the complaint that the knee has been swollen and painful rather constantly over a long period of time. This complaint is not heard often these days, but the doctor must always

difficult to grow under these circumstances. There is ordinarily a history of migratory joint pain, particularly of the small joints, before the localization in a single large joint. There may be a history or a finding of petechiae in the skin, or it may be known that the child is recovering from meningococcal meningitis.

Rheumatoid and Tuberculous Arthritis

Rheumatoid arthritis is distinguished by a history of migratory joint pain and the typical fusiform swelling of the proximal interphalangeal joints of the fingers. Tuberculous arthritis is distinguished, first, by the finding on the x-ray pictures of destruction of the joint surfaces in the nonweight-bearing portions and, second, by the fact that it is ordinarily a more indolent and slower process (although it can be acute). The finding of tuberculous processes (such as pulmonary tuberculosis) elswhere in the body, positive skin tests, as well as the inoculation of guinea pigs, are other diagnostic methods of determining tuberculous arthritis. Because of the length of time necessary to perform the guinea pig test, it is not so helpful as are other methods in the differential diagnosis.

It must be kept in mind that the septic knee may be associated with hematogenous osteomyelitis of the distal femur or proximal tibia and that successful management of the septic joint depends on the treatment of both conditions.

Acute Hematogenous Osteomyelitis of the Tibia or Femur

The child is presented with the complaint of pain which the parent states to be in or around the knee. Upon questioning, it may be apparent in fact that the pain is either just above or just below the knee joint, actually within the metaphysis of the femur or the tibia. Furthermore, it will be stated that the child is feverish. The history includes an upper respiratory infection, a sore throat, or a cut in the skin, with a localized infection surrounding it, within the last two weeks prior to the onset of the present illness. A child may or may not have injured the leg within the prior two weeks. The parent will note, however, that the child either limps or refuses to walk and complains of pain around the knee. The etiology of the process is, of course, the invasion of the blood stream by an organism, usually the *Staphylococcus aureus*, with the creation of septicemia. During the septicemic phase, the organism has alighted in the metaphysis of either the distal femur or the proximal tibia. The blood is relatively stagnant in these regions. Essentially, a bone abcess is formed, and the bone is destroyed. In children under 2 years of age, the causative organism is more commonly the *Streptococcus hemolyticus*, but in children between 2 to 14 years of age, the common organism is *Staphylococcus aureus*. In children under 2 years of age, the bone is easily and quickly destroyed, and the purulent material finds its way to a subcutaneous location with relative ease. Under these circumstances simple incision of the fluctuant mass allows evacuation of the purulent material, and the bone is more easily reconstructed than in the older age groups. Beyond 2 years of age the bone is more difficult to destroy It is more likely to become the site of chronic osteomyelitis and has more difficulty undergoing reconstruction than the bone in children under 2 years of age. Examination will reveal that the child

Complaint		Likely Diagnoses	Page
10 to 14 yr.			
Limp with or without pain in fat 12-year-old boy Limp with pain in knee of fat 12-year-old boy	(1)	Slipping capital femoral epiphysis..........	76
Any Age			
Limp	(1)	Post-poliomyelitic weakness around hip....	79
Walks with thighs together in scissors movement	(1)	Spastic paralysis around hip (cerebral palsy) . ..	80
Pain in hip associated with fever	(1)	Acute hematogenous suppurative arthritis of hip	81
	(2)	Acute osteomyelitis of femoral neck	82
	(3)	Rheumatic fever.....	82
	(4)	Rheumatoid arthritis	83
	(5)	Meningococcal arthritis	83
	(6)	Tuberculous arthritis	83
One leg shorter than other	(1)	Leg length discrepancies due to various factors (post-poliomyelitic shortening of leg, post-fracture shortening of leg, chronic osteomyelitis, tuberculous arthritis, congenital dislocation of hip, previous Legg-Perthes' disease, slipped capital femoral epiphysis, congenital hemihypertrophy, bone tumor, neurofibromatosis, arteriovenous aneurysm)	84

Congenital Dislocation of the Hip, Unilateral or Bilateral

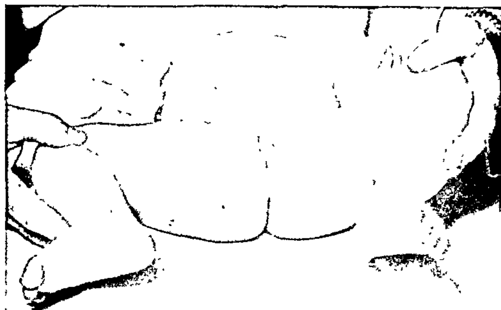
There are numerous presenting complaints in the condition of congenital dislocation of the hip. If the complaint involves a 6- or 7-month-old baby, particularly a girl, and concerns an extra fold or crease in the buttocks, the doctor should be very suspicious either of congenital subluxation of the hip or of congenital dislocation of the hip. Simply because there is an extra fold in the buttocks does not necessarily mean that there is a dislocation of the hip joint, but the possibility is so strong that every effort must be made to determine whether the hip is normal. As the child progresses to a larger, more developed general state, the complaint frequently may be that one leg seems shorter than the other and, possibly, in addition, that the short leg is turned outward. Again, this complaint does not necessarily mean that the hip is dislocated, but a thorough examination should be made with this thought in mind. When the child reaches the stage when she should normally bear weight on her leg and walk (12 months of age, on the average), the complaint by the parent may be that the child is slow in bearing weight on her legs as compared to her siblings. She may not have tried walking until 15 to 16 months of age. Associated with this may be frequent falling or limping as the child bears weight, plus the fact that one leg seems to be somewhat shorter than the other This group of complaints again points strongly to the possibility of dislocation of the hip. The complaint that the child can walk but actually waddles somewhat like a duck is strongly indicative of bilateral dislocation of the hip joints.

keep the condition in mind. Examination reveals an undernourished, underdeveloped, pale child who appears chronically ill and has a swollen knee. Examination of the knee itself reveals that there may be no particular heat to palpation or redness on inspection, but it has a boggy sensation to palpation which is quite different from the tense feeling to palpation of the effusion in acute suppurative arthritis. The boggy sensation to palpation is brought about more by a thickened and indurated synovium than by the tenseness of the fluid contained in the joint. Active and passive motions are, of course, painful, but they are not painful to the degree that is found in acute hematogenous suppurative arthritis. The suspicion that the condition is tuberculous synovitis or arthritis can be confirmed by x-ray pictures, which frequently reveal destruction of the bone, particularly in the nonweight-bearing portions, by the finding of tuberculosis elsewhere in the body, especially in the lungs, and by a positive skin test. The aspirate from such a knee should be injected into a guinea pig and cultured and smeared to test for acid-fast organisms. Treatment consists of two main types, the systemic treatment of the patient as a whole and the local treatment of the knee. The systemic treatment consists of bed rest, a high caloric and vitamin diet, and the systemic administration of streptomycin and para-aminiosalicylic acid (PAS). The local treatment of the knee consists of immobilizing it in a plaster cast to place the joint completely at rest. The position should be that of optimum function in case of stiffness or fusion by virtue of the tuberculous process. If, after a reasonable length of time (six months), it is apparent that the tuberculous process is progressing and there is further destruction, advice should be sought with regard to possible surgical treatment. Surgical treatment consists of arthrodesis of the knee, and it can be performed either with or without the additional help of a bone graft. The prognosis depends as much on the extent and severity of the other tuberculous processes in the body (for example, in the lungs) as it does upon the local condition of the knee.

DISTURBANCES OF THE HIP IN INFANCY AND CHILDHOOD

Complaint	Likely Diagnoses	Page
6 to 18 mo.		
Extra fold in baby girl's buttocks One leg seems shorter than other in girl Girl delayed in walking Girl walks with limp on one side Girl walks but waddles like duck	(1) Congenital dislocation of hip, unilateral or bilateral .	67
4 to 8 yr.		
Pain in hip or knee in boy Painful limp in hip in boy Limp in boy	(1) Legg-Perthes' disease .	74

location of the hip it may be found that when force is exerted cephalad, the greater trochanter rises in relation to the pelvis. Normally the greater trochanter does not move in relation to the pelvis when a force is applied cephalad on the lower extremity. Passive motion of the hip joint is carried out, and it is sometimes found that external rotation is marked in degree on the affected side, whereas internal rotation may be quite limited. Abduction of the affected side may also be found to be less than on the normal side. Trendelenburg's sign is sought for.



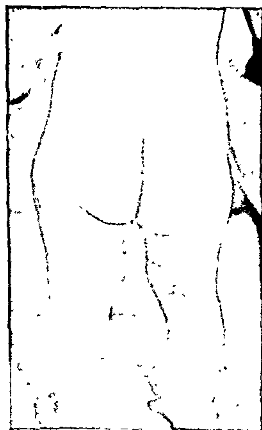
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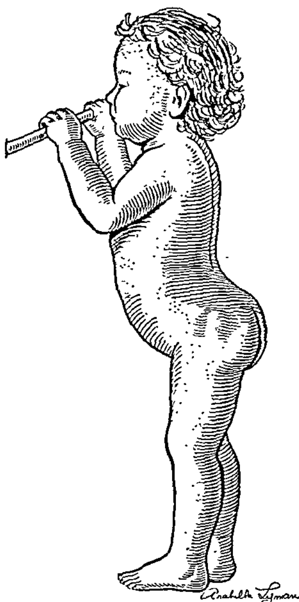


D

Fig. 33 (Continued) —For legend, see opposite page.

Examination (Fig. 33, *A*, *B*, *C*, and *D*) of a child with any of the foregoing complaints should seek to determine leg-length discrepancies and the presence of the telescoping sign. First, the leg length is taken from the anterosuperior iliac spine to the medial malleolus. Shortening of the affected leg may be found. Second, the telescoping sign is sought. With the patient on her back and with the leg held straight, a force is applied cephalad to the whole extremity while attempts at palpation of the greater trochanter are made. In congenital dis-





A *B*

[illegible] th of the folds of [illegible] of motion in the [illegible] (From Larson, [illegible] by Co.)

the pubic ramus. (Fig. 34.) The remainder of the changes visible on the roentgenograms can be deduced from the description of the pathologic anatomy. The acetabulum is shallow; the acetabular roof is sloping; there is upward displacement of the femur; and the capital femoral epiphysis is not visible or is descernible only as a small calcific dot representing the ossification center because the epiphysis is underdeveloped. Treatment for children 1 to 2 years of age consists of the following procedures. The dislocation is reduced by manipulation under anesthesia. The leg is then placed in the "frog" position (that is, there are 90 degrees of flexion of the thigh to the abdomen, the thigh is swung laterally 90 degrees from the midline, and the knees are at 90 degrees of flexion). A cast from the lower thorax over the abdomen and including both lower extremities is applied. It will be seen that the "frog" position is one of

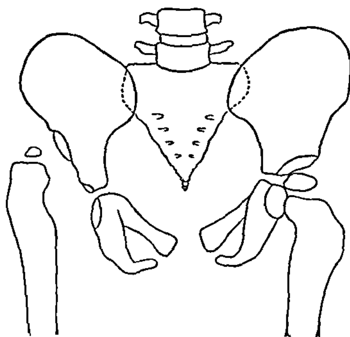


Fig 34 —Congenital dislocation of the hip Note the shallow acetabulum, the underdeveloped femoral epiphysis, the position of the femoral head, and the sloping acetabular roof. Note also the discontinuity of Shenton's line (From Larson, C. B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C V Mosby Co.)

wide abduction and marked external rotation of the hips, as well as flexion of the hips. It is sometimes also called the "90-90-90" position. (Figs. 35 and 36.)

Although numerous changes of cast may be made, the "frog" position is maintained for six to eight months, or until the acetabulum shows some evidence of development on roentgenologic examination. At the end of this period the legs are placed in moderate abduction, with slight extension of the hips and some internal rotation of the lower legs, and the knees are flexed only a few degrees. The cast, applied in this manner, is left on for four to six weeks longer. The purpose of applying the cast in the new position of moderate abduction and some extension is to gradually bring the extremity out of the "frog" position into one more nearly neutral. If the cast is removed without such an inter-

In this test attempts are made to have the patient stand first on one leg and then on the other Normally when weight is borne on one leg, the gluteus medius on that side contracts, stabilizes the pelvis on the femur, and maintains the pelvis level. However, if there is disturbance of this mechanism, the pelvis cannot be maintained level, and the opposite *normal* side falls. If weight is borne on the affected leg in congenital dislocation of the hip, the head of the femur, being outside of the acetabulum, passes cephalad, and it is impossible to stabilize the pelvis upon the femur. Therefore, the opposite normal buttocks falls. Examination is not complete until x-ray pictures of the pelvis have been taken to determine the condition of the hips.

Occasionally both hips are affected. Numerous theories as to the etiology have been suggested. Congenital and hereditary dysplasia, or underdevelopment of the acetabulum, could produce a dislocation or subluxation by affording too shallow a space for the femoral head. Nevertheless, it is entirely possible that the fault might lie primarily in a poor development of the femoral head and that the changes in the acetabulum are secondary to this. Many believe that different mechanisms may be responsible and that some cases are prenatal and others postnatal in origin. In the cases of prenatal origin it is believed that the femoral head had never been present in the acetabulum.

In the cases of postnatal origin the femoral head is believed to have migrated gradually to a position posterior and superior to the shallow acetabulum. One of the most comprehensive theories is that of faulty limb bud rotation. This theory proposes that the fault may not be locally in the hip, but that the entire limb bud is to blame. During normal development, the limb bud passes through a series of different positions and rotations. If there is inadequate, faulty, or incomplete rotation of the entire limb bud, then the femoral head may develop out of contact with the acetabulum, resulting in congenital dislocation of the hip.

In congenital dislocation of the hip the femoral head may be completely out of the acetabulum, or a lesser degree of malposition called "subluxation" may be present. Pathologically, the acetabulum is smaller than normal and is shallow, and the superior portions slope sharply upward instead of protruding laterally over the femoral head. There is a delay in the appearance of the center of the ossification of the femoral head, and hence the latter is underdeveloped. The joint capsule not infrequently surrounds the head of the femur, constricting the femur in an hourglass shape before fanning out to attach to the rim of the acetabulum. The shallow acetabulum is filled with fat and fibrous tissue. The head of the femur rises posterior and superior to the acetabulum along the wing of the ilium. Furthermore, the neck of the femur is anteverted in relation to the shaft to a greater degree than is normal

On the roentgenograms it is possible, in the normal condition, to trace a line along the inner aspects of the femur and the inferior border of the femoral neck and to continue the line in a gentle curve along the inferior aspect of the superior pubic ramus. This line is known as Shenton's line and looks not unlike an inverted parabolic curve In congenital dislocation of the hip Shenton's line is broken because the inferior position of the femoral neck is higher than

often placed in skeletal traction for a period of time. In this manner the soft tissues are sufficiently stretched so that manipulation can be successfully performed. If the child has had a manipulative reduction and has worn a series of casts for about nine months and if, during the trial of weight-bearing, the hip becomes dislocated, then open reduction is indicated. If manipulation has failed to achieve reduction and if traction followed by manipulation has also failed to gain reduction, then open reduction is indicated. Open reduction presupposes that the child is under 5 years of age. In the surgical procedure the hip joint is exposed, the hourglass constriction in the capsule is incised, the fat and fibrous tissue is removed from the acetabulum, and the dislocation is reduced under direct vision.

If the child is between 5 and 10 years of age, open reduction is usually performed in conjunction with a shelf operation. This consists of turning down a shelf of bone from the side of the pelvis so that it projects laterally over the femoral head and prevents redislocation. If the patient is 10 to 15 years of age, open reduction will probably fail. Therefore a shelf of bone is turned down over the head of the femur, and a true open *reduction* is not attempted. It is to be noted that the bony shelf is formed, surgically, superior to the femoral head wherever the latter is found. No attempt is made to alter the position of the femoral head in patients 10 to 15 years of age. The reasons are obvious. The soft tissues have become so tightly contracted that moving the femoral head back to the original acetabulum would most likely prove impossible. Furthermore, by 10 to 15 years of age a relatively deep false acetabulum, together with a surgically produced shelf of bone, will probably prove to be a more satisfactory socket for the femoral head than the original shallow (true) acetabulum. Should it be undesirable to perform one of the procedures just described, osteotomy may be carried out, and the femoral shaft can be displaced to a point nearer the center of gravity of the body. Thus the pelvic wall gains support. Consequently, the lurching gait due to the preoperative lack of support for the pelvis disappears.

The problems of congenital dislocation of the hip may be summed up in this manner. If the child is under 5 years of age, reduction by manipulation is attempted. Casts are applied in the "frog" position for seven to nine months, and then a trial at weight-bearing is carried out. If manipulation fails to achieve reduction, a preliminary period of traction is used. If the dislocation still cannot be reduced or if dislocation recurs following the application of a series of casts, open reduction is used. If the child is between 5 to 10 years of age, open reduction plus the shelf operation is used. If the child is over 10 years of age, the shelf operation alone (omitting open reduction) can be done, or angulation osteotomy can be performed.

One of the common reasons that dislocation recurs, even after treatment for nine months in casts, is that the capsule has been carried into the acetabulum in front of the femoral head at the time of manipulated reduction. Poor results have their basis in the following situations: (1) the inability to achieve reduction or to maintain it once obtained; (2) the appearance of a late change, such as Legg-Perthes' disease, which is probably an avascular necrosis; (3) a

mediary step, the child will lie in the "frog" position by preference even out of the cast. Hence, the treatment with casts lasts seven to nine months in all. The child is finally allowed a trial at weight-bearing. Roentgenograms are taken during the course of the treatment, both with the casts and periodically during the trial at weight-bearing. Figures on the success of the treatment vary considerably, but approximately 60 per cent of the patients have a good

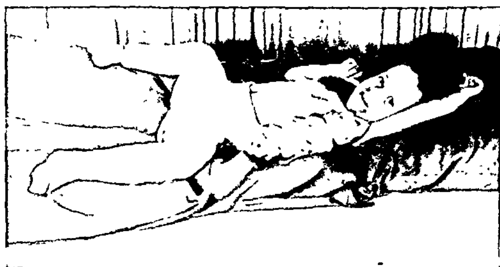


Fig 35



Fig 36

Figs. 35 and 36 —Dislocated hip in a cast Note the "frog" position. (From Larson, C B , and Gould, M : Calderwood's Orthopedic Nursing, 1957, The C V Mosby Co)

or fair result. Failure results, of course, if the dislocation recurs, which happens occasionally. In these patients, operations, described on page 73, are performed. In a certain percentage of patients, a change takes place in the femoral head which is similar to Legg-Perthes' disease and may be due to avascular necrosis.

It is not always possible to reduce a congenital dislocation of the hip by manipulation. If manipulation has failed to achieve reduction, the child is

junction with crutches; or (5) some form of leather harness to prevent the affected leg from bearing weight. Simple bed rest seems to be the best method. However, it should be carried out for one to one and one half years. This is extraordinarily difficult to do, because the child feels well and wishes to be active. Consequently, the program of bed rest requires the wholehearted cooperation of intelligent parents. It is found that it is usually wiser to institutionalize the patient in a special hospital equipped to deal with such a situation. In such institutions the patient is put at bed rest in a splint which enforces a recumbent position. There are usually several other patients present with the same disorder. Schooling, amusement, etc., are provided for the group as a whole. In such surroundings the patient with Legg-Perthes' disease is ordinarily more content to remain at bed rest and can endure his two years of treatment more easily.

If an ambulatory method of treatment is to be used, the doctor should exercise his judgment in choosing the specific type.



Fig 37 —Legg-Perthes' disease of the left hip.

If weight is borne on the hip while it is undergoing degeneration, the capital femoral epiphysis probably will heal in a deformity. The deformity is a *flattening* of the femoral head (coxa plana), together with a loss of the normal angle between the neck and the shaft (coxa vara). Not only *may* deformities of the coxa plana and coxa vara result, but also the femoral head *may* become irregular. Hence, early malum coxae senilis should be anticipated, with its attendant problems. (See Chapter 5, Disturbances of the Hip in the Adult, page 215.)

In other words, the practitioner should realize that the patient with active Legg-Perthes' disease has a large potential for further difficulty with the hip,

stiffness of the joint, (4) a residual instability which leads to a lurching gait; and (5) the presence of late malum coxae senilis due to incongruity of the joint surfaces. Again, as in Legg-Perthes' disease and slipping capital femoral epiphysis, the problem of congenital dislocation of the hip is not ended in childhood. Later disturbances arise which must be managed.

Legg-Perthes' Disease

Synonyms for Legg-Perthes' disease are coxa plana, epiphysitis, osteochondritis, osteochondrosis, and avascular necrosis. The process is similar to Kohler's disease of the tarsal scaphoid, Freiberg's infraction of the second metatarsal head, and Osgood-Schlatter's disease of the tibial tuberosity. Legg-Perthes' disease occurs in the head and neck of the femur at an average age of 7 years. Boys are more commonly affected than girls. It should be emphasized that frequently a disturbance of the hip gives rise to pain in the knee rather than in the hip. Unless the doctor keeps this in mind, he may be misled into examining the knee and neglecting to examine the hip, thereby missing the diagnosis completely On examination of the hip for osteochondritis, atrophy of the gluteal muscles may be apparent. In the early stages there may be neither shortening of the leg nor limitation of the motion of the hip. These signs are present in the more developed instances of the disease. X-ray pictures are the surest means of diagnosis There is disagreement as to where the process first starts. Some believe that the earliest sign indicated on the roentgenograms is the atrophy of bone in the neck of the femur just distal to the epiphyseal line. This area of atrophy gradually extends across the entire femoral neck. Shortly after the atrophic area appears in the neck, the femoral head (epiphysis) becomes progressively fragmented (Fig. 37), and gradual flattening occurs. The flattening of the femoral head is, of course, the basis for the name coxa plana. As in other osteochondritides, there is a stage of degeneration followed by a stage of regeneration. Pathologically, there are areas of necrotic bone in the ossification center and areas where bone is replaced by a rich granulation tissue infiltrated with lymphocytes. The fragmentation shown on the x-ray pictures is due to these irregular areas of bone replacement by granulation tissue. Furthermore, as is also true in other instances of avascular necrosis, the head of the femur is malleable and pliable during its degenerative stage and will heal in a deformity unless protected during this stage.

It is therefore obvious that the treatment of Legg-Perthes' disease must be directed toward the prevention of weight-bearing on the involved hip, especially during the stage of degeneration. The stage of degeneration requires about eighteen months, and the stage of regeneration about one year. Some cases taken even longer than two and one-half years for the cycle to be completed. In general, the earlier in life the process begins and treatment is started and the more faithfully it is carried out, the shorter is the time for the healing and the better are the results

There are several ways to prevent weight-bearing: (1) bed rest alone; (2) bed rest and a cast; (3) skeletal traction in bed; (4) a walking caliper brace applied to the affected side, with a lift to the opposite heel, used in con-

The condition of slipping epiphysis occurs usually in boys and is most often seen in those with the Fröhlich body build—the fat boy with underdeveloped genitalia. The etiology is not clear. However, the occurrence of the disease in persons perhaps suffering from a dysfunction of the pituitary gland and the fact that the slipping occurs in an area at which endochondral ossification (controlled by the pituitary) is taking place lead many to believe that it is fundamentally an endocrine disturbance. There is very little evidence to support this theory. Slipping capital femoral epiphysis occurs in persons between 10 and 15 years of age. Clinically, a fat boy around 12 years of age presents with a limp which has gradually become painful. The pain is in the hip or the knee. Pain in the knee joint is often complained of, but the hip is primarily the site of the disease.

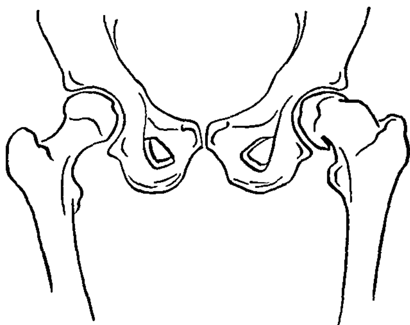


Fig. 38.—Slipping capital femoral epiphysis. Note the beaklike projection made by the head inferior to the neck and compare positions of the lesser trochanters in relation to the pelvis.

Examination in the early stages may show nothing except the slightest loss of internal rotation of the hip. It is easily understood that, as the femoral neck and shaft begin their upward and outward migration, internal rotation would not be complete and that shortening might very well be insignificant. Such a situation (that is, the sole finding of limitation of the internal rotation) is present in the so-called "preslipping" stage. The term "preslipping" is a misnomer and should be discarded. It is used to designate that stage of the disease when it is difficult, even with the roentgenograms, to be sure that there is a change in the relation of the neck and shaft to the head. Roentgenograms in the "preslipping" stage reveal a widening and irregularity of the epiphyseal line. This is caused by the following situation. As the neck and shaft move gradually into external rotation on the head, both the anterior and posterior portions of the neck at the epiphyseal line come into view. This is much as if

and at an early age he may be completely disabled, requiring reconstructive surgery for rehabilitation. These children 4 to 8 years of age constitute many of the patients with malum coxae senilis who will need arthroplasty of the hip at 35 years of age. *The problem should not be considered to have ended with the apparent healing of the process in a 4-to-8-year-old boy.*

There are two general methods of surgical attack upon Legg-Perthes' disease during the acute illness which are devised to shorten the long period of treatment of the nonambulatory patient. First, it is possible to expose the lateral femoral shaft at its junction with the greater trochanter and make multiple drill holes up through the femoral neck, across the epiphyseal plate, and into the diseased femoral head. The second method is to approach the hip joint anteriorly and to curette the diseased bone from the femoral head. Both of these methods attempt to re-establish good circulation, stimulate healing, and remove diseased tissue. Neither method is in common use because each risks damage to the remaining epiphysis, with subsequent possible worsening of the process.

In summary, Legg-Perthes' disease is an affection of the hip, probably in the nature of an avascular necrosis, the etiology of which is unknown. The disease attacks boys by perference, usually at or around the age of 7 years. The degenerative phase takes about eighteen months and the regenerative phase one year. The best treatment results are to be gained from placing the patient at bed rest for one to two years. The complications are deformities of the coxa plana and coxa vara and early malum coxa senilis. All of these are manifested by varying degrees of shortening of the leg, limitation of the motion at the hip, and pain upon either active or passive motion of the hip.

Slipping Capital Femoral Epiphysis

Slipping capital femoral epiphysis is an affection of the hip in which the head of the femur slips progressively from its position on the neck. Actually it is more in the nature of a migration of the femoral shaft and neck upward and into external rotation, with the femoral head considered as a fixed point. The slipping takes place at the epiphyseal line between the neck and the head. (Fig. 38.) Usually the process is very gradual, taking months to develop. At times, however, the capital femoral epiphysis slips completely off the neck with dramatic suddeness as a result of only insignificant trauma. For example, a patient in whom signs suggestive of a *beginning* slipped capital femoral epiphysis *have been found may have just finished consulting the physician.* Then, within the next hour, he may trip over a rug, fall to the ground, and exhibit complete separation of the femoral head from the neck. Because of the fact that the femoral head may suddenly slip completely off the neck, the condition of slipping epiphysis should be handled as an acute emergency from the moment diagnosis is made. The treatment in the early stages is a great deal simpler and the complications far less difficult if adequate therapy is instituted immediately than if delay allows moderate, advanced, or complete slipping to occur. It should be emphasized that these sudden and complete cases are in the minority. Those requiring months to develop are the common ones.

This procedure has as its drawback the possibility that the femoral epiphysis may undergo extensive aseptic necrosis due to interference with the blood supply.

In view of the previously mentioned risk of early malum coxae senilis if correction of the condition is not attempted, the procedure of osteotomy and nailing appears justified even though it is one of the most difficult technical procedures in orthopedic surgery and is attended by a high proportion of complications, such as aseptic necrosis of the head of the femur.

As an alternative procedure to osteotomy of the neck and insertion of a Smith-Petersen nail, a subtrochanteric osteotomy can be performed. In this procedure the femoral shaft is cut through just below the lesser trochanter. The femoral shaft is then widely abducted in relation to the proximal fragment containing the trochanter, neck, and the slipped epiphysis. The shaft is affixed (in the widely abducted position) to the neck and trochanter by a blade plate appropriately shaped. Such procedure has the effect of overcoming the varus position of the hip in relation to the shaft.

It is clear that treatment of a slipping capital femoral epiphysis has as one of its aims the hastening of the union between the head and neck of the femur across the epiphyseal line. The question, therefore, frequently arises as to whether this might cause shortening of the leg. Actually, the epiphysis in question contributes 18 per cent of the total length of the entire lower extremity from birth to the time of union with the neck. At the age of 12 to 13 years, when slipping is prone to occur, much of the growth has already taken place. Furthermore, unless the epiphysis is fused to the shaft by one means or another or otherwise fixated, the slipping per se will cause shortening far greater than that which will come from arresting its growth. Thus, there is indeed a certain small amount of shortening, usually less than 1.0 cm., resulting from fusion of the epiphysis to the neck. Such a small amount of shortening is negligible when compared with the result obtained if fixation of the epiphysis to the neck is not carried out.

In summary, slipping capital femoral epiphysis is an affection primarily involving the epiphyseal line of the neck of the femur. The relation of the neck and the shaft to the head is altered by a gradual migration upward, posteriorly, into external rotation of the neck and shaft upon the head. Patients are usually boys 12 to 16 years of age with the Fröhlich body build. The condition is bilateral in about 30 per cent of the patients. The complaint is pain in the hip or the knee, with limp. The outstanding clinical findings are limitation of internal rotation and shortening of the leg The condition should be considered an orthopedic emergency. Treatment is best carried out early and consists of the insertion of a Smith-Petersen nail. Patients in the most advanced stages of slipping may be treated by osteotomy of the femoral neck, with insertion of a Smith-Petersen nail, or by subtrochanteric osteotomy, with a blade plate used for fixation. Conservative treatment in either the "preslipping" or the later stages of this process is not recommended.

Post-Poliomyelitic Weakness Around the Hip

After the patient has recovered from the acute phase of anterior poliomyelitis, a limp which is obviously centered around the hip may occur. An-

a pencil were turned gradually so that the blunt end is brought into view. Thus, the roentgenogram reveals two lines which produce the appearance of a broadening of the epiphyseal line.

As the process of slipping continues, the capital femoral epiphysis, as seen on the roentgenogram, has definitely changed its relation to the neck. A beak-like projection protrudes below the femoral neck, and the epiphysis gradually assumes the appearance of a crescent. At this stage, not only is there limitation of the internal rotation, but also demonstrable shortening of the leg. The two cardinal findings of limitation of internal rotation and shortening of the leg are extremely important, since they are very suggestive of slipping capital femoral epiphysis in a patient 10 to 14 years of age. As has been intimated, the slipping process may at any time become complete, or it may continue for a while, becoming arrested in a stage of marked deformity. The late deformities which are likely to result from a slipping capital femoral epiphysis are coxa vara and early malum coxae senilis. The doctor should be aware that these children, like those suffering from Legg-Perthes' disease, may be among those patients who require arthroplasty of the hip at the early age of 35 years. The condition is not corrected even by excellent treatment during the teen-age period in many of these patients.

The treatment of slipping capital femoral epiphysis depends somewhat on the stage at which the condition is discovered. Naturally, it is preferable to make a diagnosis and institute treatment in the so-called "preslipping" stage. At this time there is so little change in the relationship between the head and neck that treatment can be confidently expected to produce a normal hip if it is undertaken forthwith. The preferred method of treatment is the insertion of a Smith-Petersen nail through the neck and into the capital epiphysis. Conservative treatment in this condition is not recommended. Some simply apply a cast, with the leg in internal rotation. Others use an internal rotation brace. The purpose of the latter is to allow the patient to be ambulatory, and yet to support the hip while maintaining a force of internal rotation. The tendency of the leg to migrate into external rotation is theoretically counteracted. If the method of Smith-Petersen nailing is used in the early stages, early protected ambulation is anticipated. The progress of *both* hips is followed with roentgenograms, since in about 30 per cent of the patients the condition is bilateral. It is particularly advisable to make an early diagnosis if the other femoral epiphysis begins to slip

In some patients the process has gone beyond "preslipping" or even moderate slipping (up to 1 cm as shown by the roentgenogram). The position of the epiphysis in the more advanced stage may be such that the insertion of a Smith-Petersen nail is impossible Again, under these circumstances, conservative therapy is not recommended The operative treatment for those patients in whom Smith-Petersen nailing is impossible is a surgical procedure which first undertakes osteotomy of the femoral neck and then insertion of a Smith-Petersen nail. The hip joint is exposed by the anterior iliofemoral approach, the neck is osteotomized, and the femoral head is replaced in normal relationship to the neck. Then a Smith-Petersen nail is inserted through the neck into the head.

thigh to such an extent that active abduction on the part of the patient is severely limited, as well as passive attempts at abduction on the part of the examiner. Examination may further reveal that both active internal rotation and active external rotation of the hips are extremely weak. Straight leg raising on each side may be markedly limited due to the spasticity of the hamstring muscles. It will be further observed that complete extension of the knee passively, as well as normal dorsiflexion of the ankle, may be impossible. The patient may walk on tiptoe, with the knees slightly flexed, and at each step, because of the spasticity of the adductor muscles, the thighs will scissor.

Conservative treatment consists of stretching the tight structures, including the Achilles tendon, the hamstring muscles, and the adductor muscles of the thigh. In addition to stretching these tight areas by physical therapy, specially designed braces or night casts which hold the foot at right angles to the shin, hold the knee in extension, and maintain both lower extremities in abduction, may be applied. Graded active resistive exercises to rotate the lower extremities in order to strengthen the weakened gluteal and deep rotator groups may also be undertaken. The radical treatment consists of performing an obturator neurectomy. A surgical approach is made, and the obturator nerve on each side of the pelvis is located and tested by electrical stimuli. The nerves are then severed. The decision to perform an obturator neurectomy should be made only by a surgeon especially experienced in surgery in patients with cerebral palsy. He should also perform the operation, inasmuch as inexperience frequently may produce unanticipated and disappointing results.

Acute Hematogenous Suppurative Arthritis of the Hip

The family doctor may be presented with a child who has complained of pain in the hip and who may have refused to bear weight on the hip. Furthermore, the parent may state that the child has seemed feverish and irritable. Examination will reveal a flushed, obviously acutely ill child, with a temperature of 103° F. In the immediate past history there may have been a sore throat within the two weeks preceding the onset of the present illness, or there may have been a break in the skin or a localized infection, such as a boil. Examination of the hip reveals that even gentle passive motion is obviously very distressing and painful. The patient does not willingly move the hip joint and usually refuses to bear weight on that extremity. The x-ray pictures of the hip are negative. The presumptive diagnosis under these circumstances is suppurative arthritis of the hip joint, which may be secondary to acute hematogenous osteomyelitis of the femoral neck. The femoral neck anatomically is within the hip joint, and, therefore, osteomyelitis of this area may actually give rise to an associated suppurative arthritis. It is well to keep in mind also that in the early stages the x-ray pictures will fail to reveal the destruction of the bone in acute hematogenous osteomyelitis. Management of a patient with suppurative arthritis of the hip includes the following. Blood culture and sensitivity tests are carried out, and aspiration of the hip joint, as a diagnostic measure, can be done. Aspiration of the hip joint is technically more [illegible]

terior poliomyelitis may, of course, produce paralysis or weakness of any of the muscle groups surrounding the hip joint, but the gluteus medius muscle is commonly the site of weakness sufficient in degree to cause a tiring and disabling limp. Examination of the hip reveals that the passive ranges of motion are likely to be normal. Active ranges may be possible in all directions, but active resistive testing will reveal deficiencies. In gluteus medius weakness, if active attempts by the patient to abduct the lower extremity are carried out against the resistance of the examiner, weakness of this motion is quite apparent. After the range of motion has been observed, the patient is directed to stand and bear weight, first on one leg and then on the other. This exercise will probably reveal a positive Trendelenburg's sign. Normally when weight is borne on one leg, the gluteus medius muscle on that side contracts, stabilizes the pelvis on the femur, and maintains the pelvis level. However, if there is a disturbance of this mechanism, the pelvis cannot be maintained level, and the opposite *normal* side falls. Assume that because of anterior poliomyelitis the gluteus medius muscle is weak. When the patient attempts to bear weight on the affected side, the gluteus medius is unable to stabilize the pelvis. Thus the *opposite* normal side of the pelvis drops, and the buttock on the normal side is observed to fall. Weakness of the gluteus medius is not the only pathologic state which can produce a positive Trendelenburg's sign (falling of the normal buttock when weight is borne *solely* on the affected limb). Congenital dislocation of the hip gives the same sign since the pelvis cannot be stabilized on the femur. Nonunion of a fracture of the femoral neck might also produce the same sign for the same fundamental reason. In other words, anything which interfers with the triangle of muscle and bone formed by the gluteus medius muscle, the neck and the head of the femur, and the wing of the ilium can produce a positive Trendelenburg sign.

Conservative treatment of post-poliomyelitic weakness around the hip joint consists of the application of an ischial weight-bearing brace. Weight is borne from the ischium on down to the heel. In this manner the pelvis becomes stabilized during gait. It should be pointed out that, in general, it is well to be sure that as much power as possible has been obtained from the gluteus medius muscle by physical therapy and exercises. That is, the patient may be given a trial of active exercises against resistance, which in this instance means active abduction of the lower extremity against resistance, for some period of time in order to demonstrate to what degree recovery of gluteus medius muscle power can be obtained. If such a period of exercising has failed to improve the gait, then bracing is a reasonable next step. In radical therapy, muscle transference is a possible type of operative procedure which is not recommended as a usual course of action.

Spastic Paralysis Around the Hip (Cerebral Palsy)

Ordinarily, patients with spastic paralysis present with complaints referable more to the general locomotor performance as a whole, but at times the presenting complaint is that the patient walks as though scissoring his legs. (See Fig. 24.) Examination reveals spastic paralysis of the adductor muscles of the

be so grave a danger to the patient not only systemically, but also functionally, that the diagnosis of rheumatic fever should not be considered until after a septic hip is definitely excluded. A history of migratory joint pain and clinical and electrocardiographic studies help clarify the diagnosis if doubt exists.

Rheumatoid Arthritis

If a child complains of hip pain and has an elevated temperature, the diagnosis of rheumatoid arthritis can be considered after excluding septic hip and rheumatic fever. The fever is usually low grade as compared to that in both septic hip and rheumatic fever, and usually a past history of pain in and fusiform swelling of the proximal interphalangeal joints of the fingers aid in differentiation. For a general discussion of the condition, see Chapter 12, Arthritis. The condition is mentioned here only because it is a consideration in differential diagnosis.

Meningococcal Arthritis

After excluding septic hip, with or without osteomyelitis of the neck of the femur, rheumatic fever, and rheumatoid arthritis as likely diagnoses in a child who complains of a painful hip and has an elevated temperature, the practitioner must consider meningococcal and tuberculous arthritis. The diagnosis of meningococcal arthritis may be very difficult to make. The distinguishing features which aid in making a correct diagnosis are the following: (1) The joint fluid may not reveal organisms on culture, since the meningococcus tends to be buried deep in the synovium rather than to grow freely in the joint fluid. (2) The patient may be recovering from a clinically apparent meningococcal cerebrospinal meningitis infection. (3) The patient may be suffering from a disease (hitherto obscured) consisting of a septicemia-like temperature course and a hemorrhagic skin rash (4) There may be a history of migratory arthralgia of the small joints during the two weeks preceding the localization of the pain in the large joint. (5) The synovitis in meningococcal arthritis tends to be indolent, chronic, and slow to recover.

Treatment consists of the systemic administration of antibiotics and surgical drainage, if it appears necessary.

There is a more complete discussion of the condition in Chapter 12, Arthritis (page 366).

Tuberculous Arthritis

Although tuberculous arthritis is uncommon today, it should not be overlooked as a likely diagnosis in a child who complains of hip pain and has an elevated temperature. It is differentiated from the other conditions discussed previously by the following facts: (1) Its onset is usually less acute. (2) The patient appears to be chronically ill, rather than acutely ill. (3) There is atrophy of the buttocks muscles. (4) Sometimes there is a history of night cry. (5) The roentgenograms usually show destructive changes in the hip joint. (6) The joint fluid may reveal acid-fast tubercle bacillus and a positive guinea pig test.

aspiration of either the ankle or the knee, and therefore should be done by someone with much experience. The fluid aspirated from the hip joint should be smeared and cultured, and sensitivity tests should be done. Systemically, the patient should be given adequate doses of the proper antibiotic. It will be noted that in the majority of instances the etiologic bacterium is the *Staphylococcus aureus.* The patient should be placed at bed rest, and the extremity should be protected, either by placing it in adhesive traction or by applying a suitable cast in a position of optimum function. If, within two to three days, the temperature is not under good control, the patient does not appear improved systemically, and the hip joint cannot be moved with improved range, then surgical drainage of the hip joint should be considered. Probably the best surgical approach for drainage is through the buttocks, reflecting the short rotators of the hip and incising the capsule of the joint posteriorly. Such a procedure allows dependent drainage.

After the patient is well along in the convalescent stage following either successful treatment by antibiotics alone or surgical drainage, physical therapy should be undertaken. This consists of assistive active motions, graduated to active and active resistive motions of the hip joint.

The differential diagnoses of the painful hip with fever includes acute hematogenous osteomyelitis of the neck of the femur, rheumatic fever, rheumatoid arthritis, meningococcal arthritis, and tuberculous arthritis. For a complete discussion of these conditions see Chapter 12, Arthritis (page 366).

Acute Hematogenous Osteomyelitis of the Femoral Neck

It may be somewhat dogmatic to separate acute hematogenous suppurative arthritis of the hip from acute hematogenous osteomyelitis of the neck of the femur, since an infection of the bone in this anatomic location will probably spread to cause a septic hip joint The clinical signs are the same in both conditions. The child complains of a painful hip, has an elevated temperature, and is systemically ill. Examination reveals pain on motion of the hip joint, and the child refuses to bear weight on the leg. The roentgenograms may be either negative or positive, depending on the time interval Ten days or two weeks are required ordinarily before bone changes are apparent.

Cultures are taken from the hip joint fluid and from the blood, and sensitivity tests are made on any organism present. Bed rest is prescribed, and some means of immobilization of the leg, either by splint or by traction, is carried out. The general systemic condition of the patient is managed by giving infusions or transfusions if necessary, and large doses of the antibiotic of choice are administered. If the patient does not improve rapidly, surgical drainage of the hip through a posterior route is performed

Rheumatic Fever

A complaint of a painful hip in a child with an elevated temperature can mean, of course, that the patient has rheumatic fever. Delaying or overlooking a diagnosis of septic hip, with or without osteomyelitis of the femoral neck, may

of anterior poliomyelitis or an illness which could be anterior poliomyelitis is helpful in reaching a decision.

In addition to anterior poliomyelitis as a possible cause, a discrepancy in leg length may be the result of injury. A fracture through an epiphyseal plate may occur and arrest the growth of that epiphysis, which will shorten the leg. On the other hand, a fracture in the shaft of one of the long bones in a child, particularly in the femur, may increase the over-all length of the extremity to such an extent that the injured extremity is actually longer. If the stigmas of poliomyelitis have not been found but the history of an injury has been obtained, x-ray pictures of the femoral shaft may reveal that the shortening is due to an old fracture. Inflammatory diseases, such as tuberculosis or chronic osteomyelitis, may arrest the growth of the extremity if the disease is situated near the epiphysis, or growth may be excessively stimulated by such processes because of a chronic increase in the vascular supply. In either event, a discrepancy in leg length results. These two reasons for a discrepancy in leg length can be suspected on the basis of a history of a previous illness, of draining sinuses, of previous x-ray pictures if they are available, or of new x-ray pictures if they seem indicated. If it is suspected that the cause of the leg-length discrepancy is a disturbance in the hip, the suspicion can be confirmed by observing the range of motion of the hip and by looking for a positive Trendelenburg's sign. If the hip is the basis for leg-length discrepancy, such conditions as congenital dislocation of the hip, coxa vara, slipping femoral epiphysis, and absorption of the femoral neck due to such processes as tuberculous coxitis or osteomyelitis can be diagnosed from the x-ray pictures. Other causes of discrepancy in the leg length are congenital hemihypertrophy, bone tumor, neurofibromatosis, and arteriovenous aneurysm.

Regardless of the cause of the leg-length discrepancy, we shall assume here that the fundamental cause, such as poliomyelitis or congenital dislocation of the hip, has been determined and that, in the past, the proper treatment procedures for the causative condition were followed. Therefore, at this point the problem to be considered is the management of the leg-length discrepancy per se and not the management of the fundamental cause. For many years, a lift in the shoe or a special constructed shoe was used to achieve equality of leg length. Now it is possible to perform a number of operations to equalize the length. It is well to realize that a discrepancy up to one inch or less should be managed simply by placing a lift on the shoe. A lift of a given amount may be placed on the heel on the outside of the shoe, and a smaller amount of lift placed inside the shoe at the heel area The sole should then have a much less degree of lift. A certain amount of height may be removed from the shoe at the heel for the longer leg. This decreases the height of the lifts necessary for the shoe of the shorter leg. In order to equalize the length of the legs, one may shorten the long leg, lengthen the short leg, arrest one or more of the epiphyses, or stimulate the epiphysis. The last method is used little, because it is not particularly successful and is difficult to control.

Operations for leg shortening are usually performed on the femur of the sound side. After the patient has attained growth, the desired amount of bone

(7) The skin test should be positive. (8) It should be possible to find evidences of tuberculosis elsewhere in the body, for example, in the lungs.

Treatment consists of immobilization of the hip in a position of optimum function, general rest for the body, a high-caloric, high-vitamin diet, and the administration of streptomycin and PAS (para-aminosalicylic acid). If destruction of the joint continues in spite of such therapy, arthrodesis is considered. It should be remembered that the general prognosis is equally dependent upon the presence of tuberculous lesions elsewhere in the body as upon the hip infection.

Leg-Length Discrepancies Due to Various Factors

Parents frequently present their children with complaints associated with the length of the legs. This complaint may simply be that one leg is shorter than the other or that one leg is thinner or smaller than the opposite leg. Sometimes the complaint may be one of a combination that the leg is shorter and that the patient limps In examining such a patient, the doctor should observe the gait and note whether on inspection one leg is in fact shorter. It is well to have the patient stand barefoot and then observe the levels of the anterosuperior iliac spine of the pelvis. Trendelenburg's sign should be sought by having the patient stand first on one extremity and then on the other unaided and observe whether the opposite buttock falls. If Trendelenburg's sign is positive, the fundamental difficulty causing the shortening of the extremity and the limp will probably be a disability of the hip, whether a dislocation of the hip joint, a weakness of the gluteus medius muscle, or absorbtion of the femoral neck due to osteomyelitis. Next, the leg length can be measured with the patient in a supine position The measurements are taken from the anterosuperior iliac spine to the medial malleolus on each side Any discrepancy should be noted. An additional method is measurement of the extremities from the umbilicus to the medial malleoli on each side. If measurement shows a leg-length discrepancy, it is well then to measure from the anterosuperior iliac spine to some convenient bony landmark around the knee, such as the tibial tuberosity, in order to determine whether the shortening is in the thigh, in the leg, or in both. Examination of the leg alleged to be short should include circumferential measurements of the thigh and calf for comparison with the normal measurements. If the practitioner has determined that there is indeed a discrepancy in leg length, he should attempt to make some decision regarding the cause of the short leg. There are a great many possible causes, but anterior poliomyelitis is the most common. Following poliomyelitis, the decrease in circulation to a badly paralyzed leg, with an attendant decrease in the amount of growth from the epiphysis in the involved extremity, could possibly cause the shortening in the leg Circumferential measurements might point toward anterior poliomyelitis as the original cause of the leg-length discrepancy if considerable muscle atrophy is present. Furthermore, a muscle examination in which active motions are made by the patient and resisted by the examiner should bring out the weakness of certain muscle groups. These tests should include the muscles around the hip, the thigh, the knee, the lower leg, and the foot In addition to findings of muscle atrophy and segmental muscular weakness within an extremity, a history indicating a previous attack

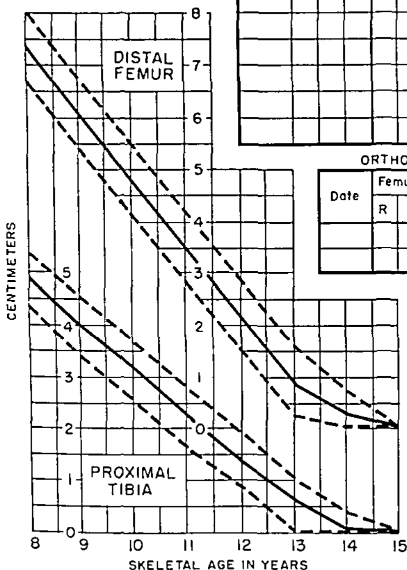


Fig 39B —Example of a table which can be used in considering an epiphysiodesis to equalize leg length in girls (From Green, W T, and Anderson, M.: J Bone & Joint Surg. 29 659, 1947)

AVERAGE CORRECTION
FROM
ARREST IN *BOYS*

Date	Height	Skeletal Age	Chronological Age	Present Length				Added Growth			
				ASS-IM		JL-IM		Femur		Tibia	
				R	L	R	L	R	L	R	L

DISTAL
FEMUR

PROXIMAL
TIBIA

CENTIMETERS

8 7 6 5 4 3 2 1 0

5 4 3 2 1 0

10 11 12 13 14 15 16 17

SKELETAL AGE IN YEARS

ORTHOROENTGENOGRAMS

Date	Femur		Tibia		Total		Descrepancy	
	R	L	R	L	R	L	Total	Tibia

BARR INDEX

Date	Right	Left

Estimation Mature Height

KEY

ASS - Anterior Superior Spine
IM - Internal Malleolus
JL - Joint Line

(Graph by Green and Anderson, J B J S, 29, 659, '47)

Fig. 39*A* —Example of a table which can be used in considering an epiphysiodesis to equalize leg length in boys. (From Green, W T., and Anderson, M · J. Bone & Joint Surg., 29 659 1947.)

tibial (and fibular epiphysis), the distal femoral, or both are the ones usually chosen. The disadvantages of epiphysiodesis are that it can be used only during the growing period and that is has a potential for a great deal of inaccuracy. Furthermore, sometimes fusion takes place on only one side of the epiphysis, and a deformity results.

The stapling of epiphyses is also used as a method of delaying growth (Fig. 40) and thus equalizing leg length. The epiphysis is exposed on both sides, and metal staples are inserted into the metaphysis and the epiphysis, bridging the epiphyseal cartilage. Usually three staples are used on each side of each epiphysis. Longitudinal growth is delayed by the force of the staples holding the epiphysis onto the shaft. At times the force of growth is such that the staple will rupture. It is said that when equality of leg length has been attained, the staples may be removed, and the epiphysis will then resume growth. This procedure is subject to many complications, one of which is that growth may not always resume.

LEG SHORTENING

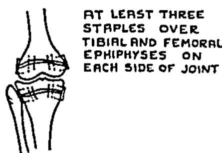


Fig 40 —Stapling used to delay growth and thus equalize leg length (From Larson, C B , and Gould, M Calderwood's Orthopedic Nursing, 1957, The C V. Mosby Co)

In summary, the operations just described to equalize leg length should be used only if the discrepancy is more than one inch and less than four inches. If the patient has a weakness in the quadriceps femoris muscle, lengthening of the tibia might increase the leverage weight so much that the weak quadriceps would no longer be able to extend the leg against gravity. If there is weakness in the gluteus medius muscle, complete equalization of the leg length might cause the patient to limp, since shortening of a leg is used to best advantage when a weakness of that muscle is present If the patient presents with an inequality of leg length less than one inch, a lift placed on the shoe is the preferred method of treatment. If the patient has a discrepancy of between one and four inches, then operative procedures are to be considered. Of the operative procedures, either leg shortening or epiphysiodesis appears at the present time to be the best. These procedures are performed on the sound extremity. If the patient is nearing the age of cessation of growth, or is older, then leg shortening is the proper procedure. Patients in the age group from 9 to 12 years are the best candidates for epiphysiodesis.

is removed from the shaft of the femur. The remaining treatment is the same as for a fresh fracture. The disadvantages of this method are numerous. A person of short stature can ill afford to lose height and may refuse the operation. Unless the disease process originally causing the shortening acted mainly upon the femur, operative intervention on the sound side might bring the knees to different heights from the ground. Furthermore, since the operation is done upon the sound side, any complication may leave the patient with two bad legs instead of one. Wound infection, loss of control of the fragments, and nonunion have been mentioned as complications of the operation for leg shortening.

Operations for leg lengthening are done usually upon the lower leg. In this procedure the tibia is divided circumferentially in the midshaft, except for a tongue of bone which is fashioned on the anteromedial tibial face. This tongue of bone is extended upward from the distal fragment into a mortise on the proximal fragment. Next, the fibula is divided obliquely just above the ankle, the surrounding fascia is severed, and the Achilles tendon is lengthened. The leg is then ready for the application of the distraction apparatus, which consists essentially of metal pins that are inserted through and through both the proximal and distal tibial fragments. These metal pins are then attached to clamps and set screws in such a way that the distal fragments can be distracted at the rate of about 1½ mm. per day. The complications have been many. When control of the fragments has been lost, bone has protruded through the skin, with attendant infection. Nonunion has resulted. Equinus and varus deformities of the foot have occurred. Palsy caused by the stretching of the vascular and nerve supplies has occurred.

Epiphysiodesis, the arrest of one or more of the epiphyses, may be used to equalize leg length. The operation consists of exposing the epiphseal line, curetting the epiphyseal cartilage, and cutting a graft of bone which crosses the epiphyseal line. This block of bone is lifted out, reversed, and replaced. The block of bone is used simply as a sort of graft to aid the fixation of the epiphysis to the shaft until union occurs.

It is obvious that epiphysiodesis shortens the leg by the amount of growth which the affected epiphysis would have contributed from the time of operative fusion until the patient reaches the age of cessation of growth It should also be clear that it is impossible to predict with absolute certainty how much growth a given epiphysis will undergo Nevertheless, a reasonably accurate prediction can be made. Roughly, the epiphyses of the leg contribute the following percentages of growth of the entire lower extremity: (1) the capital femoral epiphysis, 15 per cent; (2) the distal femoral epiphysis, 40 per cent; (3) the proximal tibial epiphysis, 30 per cent, and (4) the distal tibial epiphysis, 15 per cent. By knowing the present chronologic age, the bone age, and the height of the patient and the teleroentgenographic length of the sound femur and tibia and by using charts of percentile growth, the expected growth of an epiphysis can be calculated. It then becomes apparent which epiphysis it will be necessary to fuse. Tables are available which are simpler to use than the method just mentioned. That is, it is possible by the use of one table alone to judge which epiphysis should be fused. (Figs. 39*A* and 39*B*.) For practical purposes, the proximal

the curve. The primary curve of the pathologic type is usually rather well fixed, and the lateral bending to either side does not alter the curve a great deal. On the other hand, a "C" curve is usually flexible enough to be obliterated by positions such as lateral bending.

Postural Scoliosis.—Postural scoliosis develops in individuals with poor musculature and faulty habits of standing and sitting. The curve in postural scoliosis is flexible, mild, classified as a "C" curve, has no wedging of the vertebral bodies, and is treated by exercises and teaching the patient the proper habits of posture. The exercises are designed to increase general muscle power and general muscle tone in the proper position so that even when the patient is not thinking of his stance his muscles will tend to hold his skeleton in an improved position. Some of the common general exercises found to be helpful are as follows: (1) The patient lies prone on a firm support (many use the floor) elevates first one leg and then the other leg, and then elevates both legs together. Next, after relaxing both legs, he extends the head and shoulders. This action should actually be an extension of the shoulders in which the patient leaves his lower extremities in a prone position and elevates the upper portion of his body, extending his shoulders and scapulae backward and bringing both upper extremities upward and backward. Last, he extends both lower extremities and both upper extremities and shoulders together with the head and neck, so that he assumes the position commonly used in a swan dive. (2) Standing erect, the patient places both heels against the wall, then the calves, and then the buttocks. He next attempts to erect the trunk flat against the wall, tilting his pelvis in a manner to obliterate lumar lordosis. Last, bracing his shoulders backward in the final stance, he attempts to touch his heels, buttocks, low back, shoulders, and occiput against the wall.

Idiopathic Scoliosis.—The etiology of idiopathic scoliosis is unknown. However, its characteristics are definite and can be recognized, per se. Idiopathic scoliosis is not *simply* a "wastepaper basket" diagnosis. About 80 to 90 per cent of this type of scoliosis occurs in girls. It begins around 9 to 11 years of age. The curve ceases its development at the age of bone maturity (15 to 16 years of age). Whatever deformity is present at that time, unless corrected, will remain throughout life.

The curve is not flexible, but rather fixed There are commonly two compensatory curves and one primary curve Let us assume that the primary curve is concave to the left. Then there will be two compensatory curves concave to the right. The compensatory curves, in contradistinction to the primary curve, are likely to be flexible Furthermore, the compensatory curves involve the segments of the spine above and below the main curve. Thus, the vertebral column in idiopathic scoliosis is in the shape of an "S" rather than a "C" (compare with physiologic and postural scoliosis). There is wedging of the sides of the vertebrae in the primary curve, and also a certain amount of rotation of the vertebral bodies

The roentgenogram is of course used to determine finally which is the primary curve and its extent. A roentgenogram in the anteroposterior projection is taken with the patient erect, another is taken with the patient bending to the

DISTURBANCES OF THE BACK IN INFANCY AND CHILDHOOD

Complaint	Likely Diagnoses	Page
Curvature of spine One shoulder higher than other One hip protrudes higher than other	(1) Scoliosis	90
Back pain in 14-year-old boy	(1) Osteochondritis juvenilis deformans	96

Scoliosis

It is particularly noteworthy that patients who have scoliosis do not ordinarily complain of pain. Usually they complain that one shoulder is higher than the other, or that one hip protrudes, making it difficult for the tailor or dressmaker to fit clothing Occasionally, the parent will state that she noted a curve in the back as the child was bathing. Nevertheless, in spite of the lack of pain, if the presenting complaint concerns shoulders of unequal height, the first diagnosis to consider is scoliosis.

Scoliosis is a lateral curvature of the spine. There are several types, and treatment is based somewhat upon the kind of curvature in question. Some of the common varieties are physiologic and some are pathologic, such as postural, idiopathic, post-paralytic, congenital, post-empyemic, and those caused by diseases of the bone, for example, rickets, osteomyelitis, tuberculosis, neurofibromatosis, and metastatic tumor.

Physiologic Scoliosis

Physiologic scoliosis denotes that the condition is benign, and may be an accompaniment of the normal development and use of the vertebral column. Physiologic scoliosis appears at about 4 to 6 years of age, when the adult pattern of walking begins to be established The curve is convex to the right in about 80 per cent of the cases, that is, it is about equal to the percentage of right-handed persons. It progresses gradually with age. There is no wedging of the sides of the vertebral bodies The curve is flexible so that bending from side to side obliterates and eventually reverses the curve. It is important to distinguish it from the various types of pathologic scoliosis.

Pathologic Scoliosis

Pathologic (as opposed to physiologic) scoliosis is likely to be composed of three curves, one curve convave to a given side, one curve above the former and concave to the opposite side, and one curve below the original curve and concave to the side opposite the first curve. Hence, the scoliotic deformity is made up of one primary curve and two secondary or compensatory curves (one above and one below the primary curve) Therefore, the pathologic scoliotic deformity is often referred to as an "S" curve, rather than a "C" curve. Another point of difference between physiologic and pathologic scoliosis is the rigidity of

curves and creates a "C" curve out of the previous "S" curve. A cast is then applied over the trunk while the left lateral bending position is maintained. The cast is extended down the left leg to the knee and down the left arm to the elbow (the left arm being held at 90 degrees of abduction). (Fig. 43.) A turnbuckle is incorporated on the left side of the cast, extending from the left leg to the left arm. Wedges are cut out of the right and left lateral aspects of the body portion



Fig 42.—Turnbuckle cast with petal finish of adhesive circles (From Larson, C. B, and Gould, M: Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

of the cast so that the top portion may pivot on the bottom portion. Hinges are incorporated into the cast to allow this motion The pivot point overlies the central portion of the primary curve. As the turnbuckle is operated, the top portion of the cast moves in an arc from the original left lateral bending position to a position of correction. Since the pivot point overlies the central portion of the primary curve, the correction takes place at the primary curve, and the compensatory curves are relatively little affected.

right, and the third is taken with the patient in a left lateral bending position. That portion of the curve which is least flexible as shown on the roentgenogram is the primary curve (Fig. 41.) If one observes the spaces between the vertebral bodies in a curve, it will be noted that they are wedge-shaped, being narrower on one side than on the other. As the curve is traced upward or downward, one area will be noted where the intervertebral space is not wedged, that is, the inferior border of one vertebra is parallel with the superior border of the vertebra below. This area can be considered the end of the primary curve and the beginning of the compensatory curve.



Fig 41 —Scoliosis

There are, of course, numerous ways of treating idiopathic scoliosis If the curve is mild and if the patient is nearing the age of bone maturity (when progression of the curve will cease), it is justifiable to attempt treatment by postural exercises. Roentgenograms are taken at intervals of four months for assurance that no progression of the scoliosis has occurred.

On the other hand, if the curve is moderate or marked and if the child still has a number of years before bone maturity will arrest the curve's progress, more radical measures are indicated In these patients the curve is corrected, and a spinal fusion is performed The correction is brought about by the use of a turnbuckle body cast. (Fig 42.) The following technique is used. If it has been determined that the primary curve is concave to the left, then the patient bends the spine laterally to the left This position obliterates the two compensatory

About four to six months of immobilization in the cast after operation are required for fusion. Following this period, the back is usually protected by a brace for several more months. Therefore, a total of about one year is necessary for correction and fusion of the scoliotic deformity.

It is apparent that the correction of scoliosis by use of a body cast and spinal fusion is a formidable therapeutic program. Such a course of treatment is not to be undertaken lightly. Nonetheless, there are certain patients with idiopathic scoliosis in whom it is apparent from the first that the radical course is necessary. Naturally, between the two extreme types of patients just discussed (those in whom exercises until puberty are prescribed and those in whom a fusion is required), there are all gradations of severity of curves and of age at which the patient presents, and the physician must use his judgement in their management.

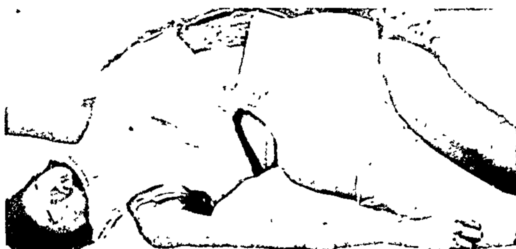
As previously stated, exercises alone, or correction by use of a body cast and spinal fusion are not the only methods of treatment for idiopathic scoliosis. Many prefer to treat the condition by applying various types of braces which exert pressure at different points and tend to counteract the forces of deformity.

In summary, the chief complaints in idiopathic scoliosis are that one shoulder is higher than the other and that the lower angle of the scapula protrudes. It is to be emphasized that pain is not ordinarily a complaint and that a deformity of the *spine* per se is not usually a complaint. The diagnosis of idiopathic scoliosis rests then upon several features. Characteristically, the patient is a girl between 10 to 12 years of age. A fixed, "S"-shaped curve occurs in the spine and is likely to increase until the patient reaches the age of cessation of growth.

Post-Paralytic Scoliosis.—One of the main types of scoliosis is that which accompanies or follows disorders of the neuromuscular system—post-paralytic scoliosis. Anterior poliomyelitis is by far the most common etiologic agent in this condition.

Anterior poliomyelitis may produce scoliosis in several ways. First, muscle weakness of an extremity with secondary disturbances of the gait in one or both legs. If a leg is handicapped by an appreciable muscle weakness, the gait is altered. As a result, abnormal stresses are placed upon the vertebral column, and scoliosis develops. Second, shortening of an extremity with secondary disturbance of the gait. Often poliomyelitis leads to inequality in the leg length. Gait is disturbed thereby, and a curvature of the spine may result. Third, weakness of the oblique abdominal muscles. It is not necessary for an extremity to be involved either by muscle weakness or by shortening for scoliosis to follow poliomyelitis. If the oblique abdominal muscles are weak, either unilaterally or bilaterally, scoliosis is very prone to occur. As a matter of fact, weakness or paralysis of the oblique abdominal muscles is one of the most common causes of postpoliomyelitic scoliosis. Last, as a direct effect upon the developing vertebral column, anterior poliomyelitis may cause a curvature by the direct effect of the acute disease on the developing vertebral column. During the acute disease, and directly following it, there may be noted premature appearance and ossification of the epiphyseal centers in the vertebral column. The ossification may be aulty and irregular, causing scoliosis.

The reverse of the above procedure is used for correction of curves concave to the right, that is, the cast is applied with the patient maintaining a right lateral bending position of the spine. The turnbuckle is inserted on the right side, running from the right leg to the right arm. If the curve is high in the dorsal spine, it may be necessary to extend the cast to include the head.



A



B

Fig 43 —*A* and *B*, Turnbuckle cast during process of wedging. (From Kleinberg, S: Scoliosis, Baltimore, 1951, Williams and Wilkins)

It may take several weeks to achieve correction, since the process should be advanced very slowly Damage to the brachial plexus must be guarded against during the entire correction process When the vertebral column is straight, or as nearly straight as is deemed possible, a spinal fusion is performed through a window cut in the dorsum of the body cast.

disease processes of the vertebrae, such as tuberculosis, osteomyelitis, and malignant tumor. He should consider also such possibilities as anomalies of the bone and an unstable back due to a mechanical situation resulting in muscle strain. Further, he should probably also consider the possibility that the pain may be due to poor posture. However, most commonly, if a 14-year-old boy complains of pain in the back without a history of major trauma, the likely diagnosis is osteochondritis juvenilis deformans. Examination of the back yields no striking findings. There may be moderate tenderness over several spinous processes,



Fig 44 —Osteochondritis juvenilis deformans. Note the wedging of the vertebral bodies and the defects of the anterosuperior and anteroinferior cortical plates.

and pain may occur upon flexion of the spine. The diagnosis is confirmed by the characteristic changes in the vertebrae as shown on the roentgenograms.

Osteochondritis juvenilis deformans, or epiphysitis as it is sometimes called, is apparently the same type of disease process as Legg-Perthes' disease of the hip, Kohler's disease of the tarsal scaphoid, and Freiberg's infraction of the second metatarsal head.

The secondary epiphyses of the vertebral bodies are the site of the disease. Thus, the superior and inferior areas of the vertebral bodies are the portions involved. The roentgenograms reveal (Fig. 44) steplike defects of the vertebrae,

As has been mentioned before, although poliomyelitis is the most common basis for paralytic scoliosis, it is not the only one. Spina bifida, with meningomyelocele and a certain degree of paralysis of the legs, is frequently associated with scoliosis. However, it is more convenient to limit the discussion to post-poliomyelitic cases, since the general principles of treatment are similar.

Paralytic scoliosis differs sharply, of course, from idiopathic scoliosis. The former occurs in boys and girls alike, rather than predominantly in girls as does idiopathic scoliosis. Paralytic scoliosis occurs at any age consistent with the contracting of anterior poliomyelitis and as a matter of fact may even start during the acute illness, while the idiopathic type occurs in girls around 10 to 11 years of age. Paralytic scoliosis is likely to progress continuously and not cease when the patient reaches the age of 15 to 16 years, as does idiopathic scoliosis.

Because of these differences, the treatment for post-paralytic scoliosis is more radical than that for the idiopathic type. Since the deformity is usually progressive, correction in a body cast and a spinal fusion are indicated. If this is not done, fascial transplants from the pelvis to the costal cage to strengthen weakened abdominal muscles, or similar procedures, can be carried out. Little can be hoped for from exercises, and braces are not so efficient in arresting the process as is a spinal fusion. The chief complaint of patients with post-poliomyelitic scoliosis is that one shoulder is elevated, that the "shoulder-blade" protrudes, *or that the back is curved. Diagnosis depends upon the finding of stigmas of* poliomyelitis, such as spotty muscle weakness or a shortened leg, together with a past history of a febrile illness compatible with anterior poliomyelitis.

The largest groups of cases of scoliosis are among the types just discussed: physiologic, postural, idiopathic, or post-paralytic.

A few cases fall within other categories. Congenital scoliosis is due to some congenital anomaly in the spine, such as a hemivertebra. Certain pulmonary diseases, such as empyema or tuberculosis, with a large amount of scarring can deform the spine. Operations of an extensive nature upon the thorax can pro*duce the same condition. Diseases of the vertebrae, such as rickets, osteomyelitis,* tuberculosis, neurofibromatosis, and metastatic tumors, can produce a scoliotic deformity. Scoliosis can be associated with cerebral palsy and with progressive neuromuscular diseases, such as progressive muscular atrophy. All of these causes account for fewer cases of scoliosis than those classified as idiopathic and post-paralytic.

It may be well to point out that the scoliosis due to neurofibromatosis has a greater tendency to become progressive than apparently has been generally appreciated heretofore Hence, spinal fusion should be used in treatment if the deformity shows evidence of progression.

In general it is a good policy to follow the ordinary case of scoliosis (regardless of its probable cause) with roentgenograms, taken at least every four months, as a means of determining whether progression of the deformity is occurring.

Osteochondritis Juvenilis Deformans

If a 14-year-old boy complains of pain in the back which is gradual in onset and unassociated with major trauma, the practitioner must consider a group of

DISTURBANCES OF THE NECK IN INFANCY AND CHILDHOOD

Complaint	Likely Diagnoses	Page
Holds head tilted to one side	(1) Congenital torticollis due to muscle contracture	99
	(2) Congenital torticollis due to bony abnormality, for example, hemivertebra	99
	(3) Torticollis due to visual disturbances	99
	(4) Torticollis due to unilateral cervical lymphadenopathy.	101
	(5) Torticollis due to traumatic rotary subluxation of cervical spine	101

Torticollis Due to Congenital Muscular Contracture, Congenital Bony Abnormalities, and Visual Disturbances

Ordinarily the parent brings the child to the physician at a very early age with the complaint that the child holds the head tilted to one side or is unable to hold it erect. The diagnosis of torticollis is usually very simple to make on the basis of inspection alone, since torticollis is the term applied to that deformity in which the head is tilted to one side and rotated to the opposite side. (Fig. 46.) There can be several different causes of the deformity. The common cause is a contracture of the sternocleidomastoid muscle. The contracture arises from a band of fibrous tissue within the muscle, probably the result of an organized, intramuscular hematoma However, a certain number of cases are due to congenital malformations of the cervical vertebra, and therefore an x-ray picture of the neck should be taken to determine whether a congenital anomaly is present. Certain diseases of the bone likewise may be responsible for the position of torticollis in a child, and therefore roentgenograms should be made to confirm the diagnosis. Furthermore, a few cases are due to disturbances of vision in which the child sees things in a normal fashion only when the head is tilted. This diagnosis is an extremely difficult one to make and usually should be considered only when the other more common causes of torticollis have been considered and ruled out, and it should be confirmed by an ophthalmologist.

In examining the child with typical torticollis, palpation will reveal a firm, contracted sternocleidomastoid muscle. If the deformity remains untreated, it will progress to the stage where asymmetry of the face develops. The aspect of the face which is inclined downward toward the shoulder and chest becomes smaller than the opposite side, which is positioned outward and upward. The ears likewise become asymmetrical. Treatment for the patients with a mild condition which is diagnosed early consists of physiotherapy aimed at stretching the contracted muscles. Positioning the child in his crib to prevent his assuming the position of torticollis is a sound procedure. Interesting toys can be placed on the side of the crib to attract the child into a position contrary to the deformity. Sometimes stretching of the neck is carried out by the physical therapist, and then a supportive bandage or even plaster splint is applied. In patients with a more severe condition or for whom conservative therapy has failed, operative section of both the sternal and clavicular heads of the contracted sternocleidomastoid muscle is carried out. (Fig. 47.) It is reasonable to persist in conservative therapy up until the age of about 1 year, at which time operative intervention should be considered.

and the defects are characteristically situated mainly in the anterior portion of both the superior and inferior cortical plates. Fragmented ossification centers are present in these steplike defects. It is easily understood that when the process heals there may be a loss of bone substance at the affected sites, so that wedging of the vertebrae results. (Fig. 45.)

Associated with osteochondritis of the secondary epiphyses of the vertebral bodies are the so-called Schmorl's nodules. Schmorl's nodules are essentially ruptures of the nucleus pulposus into the vertebra from the superior and inferior aspects of the cortical plates. The defects are ordinarily situated in the posterior part of the body. Like epiphysitis elsewhere in the body, osteochondritis juvenilis deformans occurs at an age when the secondary epiphyses are present and most

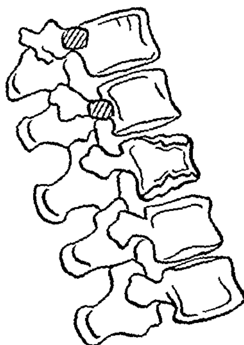


Fig 45 —Healed osteochondritis of a vertebral body Note that both the inferior and superior surfaces are involved in the wedging (contrary to the usual case in compression fractures where the superior aspect is ordinarily involved while the inferior surface is spared)

active. Therefore, the disease may be suspected in a patient from 12 to 18 years of age. The disease may involve only one vertebra, but, on the other hand, may involve almost every vertebra at the same time.

Treatment is aimed at preventing later deformity The back is supported by a brace, all strenuous activities, such as sports and heavy lifting, are forbidden, and the patient is advised to sleep on a firm mattress, with a bedboard beneath it, for added support. If the symptoms are excessive, bed rest is advised for a short time

Like other instances of osteochondritis, in the vertebral column the disease undergoes a phase of degeneration and regeneration. Treatment with the brace and bedboard may be discontinued when healing is demonstrated on the roentgenograms. Relief of pain as a criterion for cessation of treatment is unreliable.

Torticollis Due to Unilateral Cervical Lymphadenopathy

It is of course a simple matter to recognize the usual case of congenital torticollis due to muscle contracture, since it ordinarily presents at birth and since the tight muscle characteristic of the condition can be palpated. If the history, on the other hand, shows that the child was seemingly normal at birth and if the deformity has arisen later, the doctor must think of torticollis due to unilateral cervical lymphadenopathy as the fundamental cause. The pain attendant upon the swollen cervical glands causes the child to assume the protective position of torticollis. Treatment for the basic cause of the inflammation of the glands readily corrects the deformity.

Torticollis Due to Traumatic Rotary Subluxation of the Cervical Spine

Congenital torticollis due to muscular contracture is ordinarily discovered in the neonatal period, and torticollis due to unilateral cervical lymphadenopathy occurs in infancy, but torticollis due to traumatic rotary subluxation of the cervical spine occurs more often in older children.

While running, a child may suddenly turn the head to one side, hear a click, and then discover that his head is held in the position of torticollis. A partial dislocation at a set of cervical facets has occurred during rotation of the head and neck.

The most rapid treatment consists of using head-halter traction with the patient in a recumbent position. Often during a forty-eight-hour period the range of motion of the head and neck will be normal, the patient will be free from pain, and no torticollis will be apparent on inspection. However, traction should be continued as long as necessary (even five to seven days) to gain relief. If traction fails in this length of time, experienced advice should be sought.

After the period of traction, it is advisable to afford protection by a collar of sheet wadding and Ace Bandages, a plaster cast, or a brace for two to four weeks

DISTURBANCES OF THE UPPER EXTREMITY IN INFANCY AND CHILDHOOD

Complaint	Likely Diagnoses	Page
Inability to move arm properly (including holding hand clenched, inability to dorsiflex wrist and move thumb properly)	(1) Brachial palsy	102
	(2) Cerebral palsy (spastic paralysis)	103
	(3) Post-poliomyelitic weakness	104
Inability to move arm properly, associated with pain and swelling of the shoulder and elevated temperature	(1) Acute hematogenous suppurative arthritis	105
	(2) Rheumatoid arthritis	105
	(3) Rheumatic fever	105
	(4) Meningococcal arthritis	105
	(5) Acute hematogenous osteomyelitis	106

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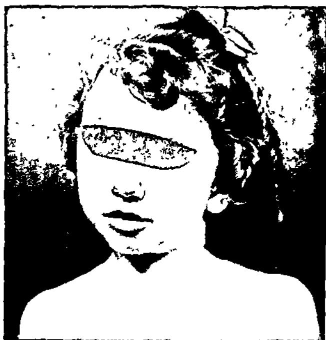


Fig 46 —Left torticollis before correction Note asymmetry of the face, rotation of the head to the right, and tilt of the head toward the affected side (From Larson, C. B, and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co)

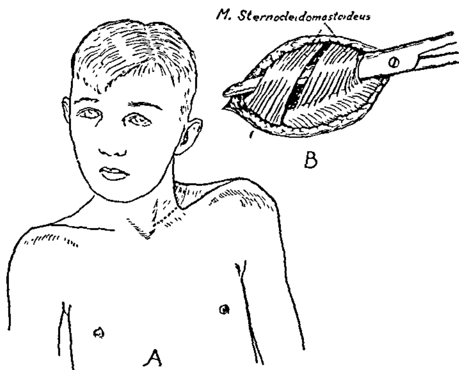


Fig. 47.—Operation for torticollis *A*, Line of skin incision. *B*, Clavicular and sternal attachments of sternocleidomastoid muscle withdrawn from wound and divided. (From Speed, J. S, and Knight, R. A : Campbell's Operative Orthopaedics, 1956, The C. V. Mosby Co.)

a difficult delivery, the upper extremity may be stretched away from the head and neck to such a degree that the nerve roots of the brachial plexus are injured, or the nerve roots may be overstretched to such a degree that they are temporarily paralyzed. In either event, a disability of the upper extremity, temporary or permanent, may result. There are several types and grades of severity of obstetric palsy affecting the upper arm and shoulder. Examination reveals that the baby has a tendency to hold the upper extremity in adduction and internal rotation. Further examination will reveal that abduction of the shoulder or external rotation at the shoulder is not carried out during the motions and movements that a normal baby makes with the upper extremity. In the early stages, support of the the arm at 90 degrees of abduction for several months is indicated. If the injury has been a simple stretching of the nerve roots, considerable recovery can be anticipated. If the injury has been a tearing of the nerve roots, recovery will not be forthcoming. The results from operative intervention are not encouraging. *Therefore, at the end of a period of support of the arm in abduction*, the permanent residual damage will become apparent. If the patient has been presented for the first time in childhood instead of infancy, a contracture in adduction and in internal rotation of the shoulder and upper extremity will have already developed. In these patients it is possible to correct the deformity and to improve function somewhat by severing the insertion of the muscles responsible for the contracture and/or performing a derotational osteotomy. Derotational osteotomy consists of cutting through the proximal shaft of the humerus and rotating the distal fragment externally the desired number of degrees.

Cerebral Palsy (Spastic Paralysis)

If the complaint is that the child holds the arm close to the side of the body or clenches the hand continually, one should consider spastic paralysis. It is true that patients with cerebral palsy have so many complaints referable to so many parts of the locomotor system that usually a complaint with regard to the arm or hand per se is very rare. Examination of the child will usually show that not only the shoulder is involved, but also the elbow, wrist, and fingers. Further examination will very likely reveal spasticity of the lower extremity on the same side Examination of the shoulder reveals that passive abduction is very poor because of the powerful spasticity of the adductor muscles. Likewise, passive external rotation of the shoulder will be very difficult because of the power of the spastic internal rotators. Local treatment for the shoulder consists of physical therapy in the form of repeated stretching of the shoulder and upper extremity into abduction at the shoulder and external rotation of the humerus If these measures are not sufficient to achieve satisfactory range of motion, then operative procedures, which sever the contracted adducing muscles and the contracted muscles of internal rotation, can be performed. This operative work should only be done by a surgeon expecially qualified in the field.

Rarely, the parent may complain that the child holds the hand and wrist clenched Ordinarily, the parent has complained of such general locomotor deficiencies that the diagnosis of cerebral palsy is apparent. However, if the presenting complaint should be that the hand and wrist are held clenched, the

Complaint	Likely Diagnoses	Page
Inability to move the arm properly, associated with pain and swelling of shoulder and normal or low-grade temperature	(1) Tuberculous arthritis	106
Refuses to move arm after injury	(1) Pseudoparalysis due to trauma	107
Fixed flexion of distal phalanx of thumb	(1) Flexion contracture due to tight fascial bands	107

Excluding fractures and dislocations, a complaint which involves the upper extremity in a child is generally due to brachial palsy, cerebral palsy, anterior poliomyelitis, or infections of the bones and joints, such as acute hematogenous osteomyelitis, the various suppurative arthritides, tuberculosis, and rheumatic fever The age of the patient and the history will have particular bearing on which of the possibilities will be the correct one. In the *newborn infant* a complaint of inability to move the arm properly, especially following a difficult delivery, leads almost exclusively to the diagnosis of brachial palsy if fractures are ruled out. Cerebral palsy should naturally be considered under these circumstances, but the observations usually made in children with cerebral palsy are not noticed in the newborn infant, but later on in infancy. Furthermore, the complaints in cerebral palsy are more widespread and cognate to the whole general picture of locomotor deficits. Hence, in the *newborn infant* the complaint of improper use of the arm is usually due to brachial palsy.

Nonetheless the same complaint in infancy can be interpreted to mean cerebral palsy, and a search should be made for other supportive physical findings, such as spasticity in the legs, inability to sit, stand, or walk at the average age, etc. To pursue the same complaint as it appears later on in childhood, it is noteworthy that then the chances are that the basic difficulty is post-poliomyelitic paralysis. To differentiate post-poliomyelitic weakness from both brachial palsy and cerebral palsy is the history of a normal function prior to the onset of a febrile illness. Notwithstanding the apparent simplicity of these facts, if there is an elevation of the temperature with the same complaint of improper use of the upper extremity in the newborn infant, the infant, or the child, the diagnoses of brachial palsy, cerebral palsy, or poliomyelitis should not even be considered until it has been proved beyond doubt that the patient does not have acute osteomyelitis or suppurative arthritis.

Therefore the age, history, and apparent general condition of the patient are especially important to the diagnosis when there is a general loss of motor function involving the upper extremity.

Brachial Palsy

If the presenting complaint in a newborn infant is that he does not move the upper extremity properly, the physician should first consider the possibility of brachial palsy or birth or obstetric palsy, as it is sometimes called. During

support for the hand and wrist in dorsiflexion by means of a leather gauntlet or cuff in order to place the fingers of the hand at the best mechanical advantage. Operative measures, such as arthrodesis of the wrist in a cock-up position, can be undertaken. Tendon transference can be considered also.

A very common aftermath of anterior poliomyelitis is paralysis of the intrinsic muscles controlling the action of the thumb. The complaint of the parent will be that the child cannot bring his thumb around to make a pinching motion with his hand. Examination will reveal atrophy of the thenar eminence. It will be noted that the thumb is used to adduct toward the index finger, but that it will be impossible for the child to roll the thumb into a position opposite the fifth, fourth, third, or index finger. It may be perfectly possible for him to flex and extend the distal phalanx of the thumb. However, the function of opposition of the thumb is of prime importance, and its loss results in a grave disability of the hand as a whole. This disability is sometimes called opponens paralysis. The corrective procedure is ordinarily operative and consists of a tendon transference from a muscle tendon system known to be adequately powerful through a pulley system in the hand. The tendon is attached to the metacarpal bone in the thumb in a manner to produce opposition of the thumb as the patient does a flexing action with the fingers.

Acute Hematogenous Suppurative Arthritis, Rheumatoid Arthritis, Rheumatic Fever, and Meningococcal Arthritis

If the presenting complaint is a swollen, painful shoulder in a child with a fever, one of the first thoughts in diagnosis should be acute hematogenous suppurative arthritis. Following an upper respiratory infection or a break in the skin with a surrounding area of infection, a child may suffer a transient or more sustained septicemia, and the organism may lodge in the shoulder joint. Examination reveals a sick, irritable, flushed child, with a temperature of 102 to 103° F., who will not use the upper extremity and complains of pain around the shoulder joint. The x-ray pictures are negative. Management should include several procedures. A blood culture should be taken, and the organism should be tested for sensitivity. The shoulder joint should be aspirated, and the material cultured and smeared. Aspiration of the shoulder joint is considerably more difficult than aspiration of the knee or the ankle and should be done by one of sufficient experience. The shoulder joint should be placed at rest, preferably in a splint or cast, in a position of moderate abduction. The patient should be treated systemically with the proper antibiotic. Supportive therapy includes infusions or transfusions. If, within two to three days, the fever is not brought under control, the swelling, heat, and redness surrounding the shoulder is not subsiding, and passive motion of the shoulder joint is still very difficult, incision and drainage of the shoulder joint should be considered.

Differential diagnosis should include consideration of the following conditions: (1) rheumatoid arthritis, in which there is a history of pain in the small joints, particularly the proximal interphalangeal joints, and possible swelling of a fusiform nature around the proximal interphalangeal joints; (2) rheumatic fever, which can be ruled out by electrocardiographic changes and mi-

practitioner should immediately consider spastic paralysis and look for stigmas of cerebral palsy, such as a flexional contracture of the elbow, an adductional and internal rotational contracture of the upper arm, spasticity of the heel cord, flexion of the knee, and an adduction deformity of the hip of the lower extremity of the same side Examination may reveal that the wrist is held in flexion, the thumb is held in the palm of the hand, and the fingers are flexed over the thumb. Local treatment of such a disturbance conservatively consists of repeated stretching and physical therapy of the fingers, wrist, and thumb to achieve extension of the fingers, abduction of the thumb, and dorsiflexion of the wrist. Night casts may be applied, with progressively more correction incorporated as time goes on. Occupational therapy may be given to train certain of the gross motions of the wrist and the hand and may be directed toward teaching the patient to use the affected hand as an assisting hand rather than as the major hand. At times, a neurectomy may be performed to decrease the power of the flexors, or this may be done in association with arthrodesis of the wrist joint. Operations of this type should be performed only by those especially trained and experienced in surgery in the spastic child.

Post-Poliomyelitic Weakness

A complaint of inability to abduct the upper arm at the shoulder, provided of course that it is *not* in an infant who has just been born after a difficult delivery, should bring to mind a possibility of paralysis of the deltoid muscle following anterior poliomyelitis. Examination reveals that passive motion of the shoulder joint is normal, or very nearly normal. There is, on inspection, obvious atrophy of the shoulder girdle muscles, including the deltoid, supraspinatus, and infraspinatus. If the arm is placed in an abducted position, the patient maintains it only with great difficulty and gradually loses the position of abduction as the shoulder and arm sink slowly to the side A history of previous anterior poliomyelitis should be sought in such a patient, and the stigmas of the disease in other areas of the body should be investigated (for example, foot drop or weakness opposition of the thumb, etc.) Treatment of post-poliomyelitic paralysis of the shoulder girdle, with loss of abduction at the shoulder, depends upon whether the process is relatively recent or quite old If the acute attack of anterior poliomyelitis is very recent, then physical therapy consisting of muscle re-education, with active assistive motions graduated to active resistive motions, should be engaged in, in order to achieve as much active muscle power as possible. If, however, the acute disease has occurred several months previously, then radical therapy is indicated The radical therapy consists of performing an arthrodesis of the shoulder joint at a position of abduction of the humerus on the scapula in order to place the entire extremity at better mechanical advantage and to use to better advantage any of the muscle power the patient does have.

On occasion, the presenting complaint is that the child is unable to dorsiflex the wrist. The clinical examination will reveal that active dorsiflexion is either very weak or impossible. The stigmas of poliomyelitis may be found in selected areas elsewhere in the body. Conservative treatment consists of

is complained of upon passive motion, and active motion may be refused by the patient. X-ray pictures ordinarily reveal the destruction of the bone associated with tuberculous arthritis. Treatment should consist of immobilizing the shoulder joint in a cast in a position of optimal function in case of later ankylosis. Systemic treatment with streptomycin and para-aminosalicylic acid should be carried out. The general supportive measures of bed rest and a diet high in calories and vitamins should be provided. Arthrodesis should be considered if the lesion worsens in spite of this regimen of treatment.

Pseudoparalysis Due to Trauma

Occasionally the practitioner will encounter an upset parent of a child who is usually 2 to 5 years of age. The history is that the parent had grabbed the child by the hand and pulled him forcefully in a given direction to prevent him from running across a street or otherwise endangering himself. The history will go on to state that the child cried out in pain immediately and cried for sometime thereafter. Then it was noted that he refused to use the entire upper extremity. The parent is obviously upset, believing that he has been responsible for great injury to the child. X-ray pictures of the shoulder and upper extremity are taken, more to reassure the parent than to confirm any suspected fracture or dislocation. The parent should be reassured that within two to three days the child will again use the upper extremity in a normal fashion. If, however, the difficulty persists, partial subluxation of the radial head should be considered, and expert help should be sought.

Flexion Contracture Due to Tight Fascial Bands

Only occasionally will a child be brought to the doctor with the complaint that the thumb is always held in a bent position. Fixed flexion of the distal phalanx of the thumb will be found. This is due to constriction of the flexor tendon by tight fascial bands. Treatment consists of operative release of the tendon by severance of the bands. If release is not performed, more severe deformity of the thumb may occur because of the limitation of the normal growth of the thumb.

ANTERIOR POLIOMYELITIS

Textbooks on medicine and pediatrics should be consulted for information on the epidemiology, clinical course, diagnosis, etc., of anterior poliomyelitis. We intend to present here only those features which should be emphasized for the proper orthopedic management of patients with anterior poliomyelitis.

The disease is caused by a virus which attacks, by preference, the brain and spinal cord. The anterior horn cells (motor cells) of the spinal cord are especially attacked. However, other areas of the cord suffer as well. Furthermore, the brain reveals many foci of damage. The pathologic process is usually spotty in distribution. A given anterior horn cell may be entirely killed by the disease, or it may simply be injured. If it is simply injured, it can still maintain the capacity for full recovery. (Fig. 48.) Again, instead of being

gratory pain in other of the large joints (do not consider rheumatic fever until acute sepsis of the joint has been completely excluded); (3) meningococcal arthritis, which can be differentiated by a history of meningococcal meningitis or a condition consistent with meningococcemia, with hemorrhagic skin lesions, and by the fact that the joint fluid usually shows no growth, inasmuch as the meningococcus is very difficult to grow in culture from joint fluid; (4) tuberculous arthritis of the shoulder joint, which is ordinarily more indolent, and in which the patient is chronically rather than acutely ill and bone destruction is present as revealed by x-ray pictures; and (5) acute hematogenous osteomyelitis, which is more difficult to distinguish, although the x-ray pictures eventually will show destruction of the bone; bone tenderness should be sought; passive motion can be carried out without too much pain if the process is osteomyelitis rather than acute hematogenous suppurative arthritis.

Acute Hematogenous Osteomyelitis

The complaint of a painful, swollen shoulder, with a temperature elevation, in a child can be due not only to acute suppurative arthritis, but also to acute hematogenous osteomyelitis. In both instances the child complains of pain in the shoulder, appears acutely ill, and refuses to use the upper extremity. In both instances the temperature elevation may reach 102 to 103° F. Theoretically, it should be possible, by eliciting bony tenderness, to arrive at a diagnosis of acute hematogenous osteomyelitis as opposed to acute hematogenous suppurative arthritis. However, from a practical standpoint, it is very difficult to distinguish the two in this region, and both may exist at once, infection of the joint being secondary to infection of the bone. If the shoulder joint can be aspirated and a purulent material obtained, a diagnosis of suppurative arthritis or both suppurative arthritis and acute osteomyelitis is, of course, made. If, on the other hand, the x-ray pictures reveal destruction of the bone in the metaphysis of the humerus, the diagnosis is acute hematogenous osteomyelitis. Treatment is very similar in both conditions. A blood culture should be made to determine the etiologic organism and to note its sensitivity to antibiotics. The patient should be treated systemically with adequate doses of the antibiotic of choice, and supportive treatment should include infusions or transfusions. The affected part should be placed at rest. If the tenderness and pain do not subside and if the temperature does not fall satisfactorily, advice should be sought with regard to operative procedures designed to drain the bone abscess in the cancellous bone of the proximal metaphysis of the humerus.

Tuberculous Arthritis

If the complaint is a painful, swollen shoulder, without elevation of the temperature, or with very little elevation of the temperature, and particularly if the history is relatively long standing, a diagnosis of tuberculous arthritis of the shoulder joint should be entertained. Examination reveals an indolent swelling around the shoulder which is not particularly hot to palpation. Pain

within the muscles, or it may be due to lesions caused by the virus in portions of the cord or brain other than the anterior horn cells. It does not seem likely that it is due to meningeal irritation in the same manner as is the opisthotonos of cerebrospinal meningitis or the spasms of other diseases with meningeal irritation. It should be emphasized that the muscle spasm of anterior poliomyelitis is a cause of pain and may also be a cause of later deformity.

It is not our intent to enter into dispute with regard to the Kenny concept and treatment of this disease. However, it is well for the reader to be informed about the terms and their meanings in this method. It is stated that in anterior poliomyelitis, the patient loses mental awareness of a given muscle; that is, the muscle is *alienated* and not paralyzed. (No claim is made that muscles cannot be paralyzed.) Therefore if a muscle is simply alienated, return of the function could be expected if the patient were taught mental reawareness of the muscle. Substitution is also emphasized; that is, a patient with weakened muscles might attempt to perform a given task by substituting a strong muscle group for the weakened muscle group. The difficulty is that the strong muscles (used as a substitute) may be antagonistic to the ones which should have been used. Therefore, the weakened muscles may be further alienated if the patient is allowed to "substitute." Another factor is that of incoordination. Incoordination as used in the Kenny system is not incoordination as it is ordinarily understood. It is used more to indicate a misfiring of a nervous impulse; that is, the patient may attempt to contract a certain muscle, and instead of that muscle undergoing a contraction a neighboring muscle does so.

Whether one agrees with the Kenny concepts or not, the following clinical features are present in the patient with acute anterior poliomyelitis. The child is acutely ill with a severe systemic disease. He is irritable, and touching or disturbing him causes pain. There may be weakness or complete paralysis of one muscle, one muscle group, an entire extremity, or any combination of extremities, together with weakness of the muscles of the trunk and neck. Fully as important as the paralysis is the muscle spasm. The muscle spasm is painful, and stretching of the spastic muscles causes pain. The spasm occurs most commonly in the erector spinae muscles of the back and the hamstring muscles of the thigh but can occur in many other locations. Next there is a severe disorganization of the locomotor pattern, regardless of the terms one may use to describe it The Kenny system uses the terms of alienation, incoordination, and substitution.

It is from this background of muscle paresis and paralysis, muscle spasm, and disorganization of the locomotor pattern that the deformities develop, and they may develop in several ways Muscle imbalance is obvious. A powerful muscle group inadequately opposed by a weaker muscle group will pull a portion of an extremity into a deformity Muscle spasm may also be a factor. A tight, painful muscle may cause a deformity even if opposed by muscles of normal or nearly normal power. Deformities may develop in other parts of the body by virtue of a disturbance in the gait caused by weakness in an extremity. For example, a simple foot drop may disturb the gait so badly that a deformity of the spine develops

either destroyed or injured with the capacity to recover, a given anterior horn cell may simply be blocked physiologically and thus have the capacity to recover. Several anterior horn cells go into the formation of a single motor nerve. Therefore, it is possible to damage a few, many, or all which make up a given motor nerve. Hence, in terms of muscle function, in the pathologic process a given muscle may be weakened only, or it may be completely paralyzed. If the muscle is weakened only in the acute stage, then some or even complete return of muscle power can be anticipated. If a muscle is completely paralyzed in the acute stage, some return of power may, of course, ensue, but there is usually a more severe degree of injury and a more extensive degree of involve-

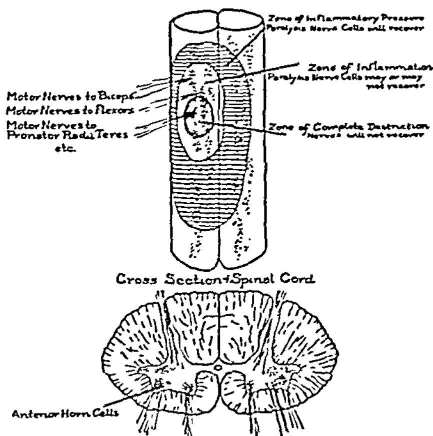


Fig 48 - Schematic drawing of spinal cord showing method of attack of poliomyelitis. (From Larson, C. B., and Gould, M. Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

ment of the cord by the virus. In terms of an entire extremity, in the pathologic process one muscle, or one muscle group, may be either weakened or completely paralyzed, or all muscles of an extremity may be partially or completely paralyzed. All sorts of patterns of muscle power can be present. One of the diagnostic signs pointing to anterior poliomyelitis is a difference in the degree of the weakness and power in the various muscle groups of an extremity.

In addition to the various patterns of muscle weakness in the acute stage of the disease, a very important finding is that of muscle spasm. The reason for the muscle spasm is not clear. The process may be due to local factors

dition with lateral instability as well as a foot-drop deformity. It is possible by the use of arthrodesis to stabilize the foot-drop deformity so that excessive lateral motion is wiped out, and the foot is prevented from falling into an undesirable degree of equinus.

In general, arthrodesis is a superior method to that of tendon transference. However, it is necessary to decide the issue for each specific problem.

To summarize anterior poliomyelitis and its treatment, the following is pointed out. The disease attacks the brain and spinal cord in numerous areas and in a spotty fashion. Various degrees of muscle weakness in a number of patterns are present. Muscle spasm and its attendant pain is as important as the muscle weakness. There is a severe disorganization of the locomotor pattern. Treatment is divided into certain types of physical therapy at first and reconstructive measures later. Recovery is the most rapid within the first four months or so following the initial attack. The operative measures are tendon lengthening, tendon transference, and arthrodesis either alone or in combination with operative procedures on the tendons.

CEREBRAL PALSY

Cerebral palsy is a term applied to a group of more or less distinct disturbances which are the result of brain injury. The injury may be due to a number of different underlying factors which occur before birth, during birth, or in childhood.

Following are some of the causes of brain damage during prenatal life. If the mother contracts German measles during the first trimester of pregnancy, the child will most likely have cerebral palsy. Incompatibility of the Rh factor between the mother and father may be responsible for brain damage in the child. If the pregnant woman has repeated episodes of vaginal bleeding of important proportions, the offspring may exhibit evidences of locomotor disturbances. In some victims it is believed that developmental features alone are the basis for cerebral palsy; that is, certain areas of the brain simply do not develop normally, and the results are the expected functional incapacities.

A second group of causes of cerebral palsy occurs during labor and delivery. The child's brain might be damaged because of lack of oxygen if the umbilical cord is wrapped around the neck, causing the cord to become compressed. Furthermore, many of the obstetric difficulties, such as cephalopelvic disproportion, can result in general injury to the child's head sufficient to leave residual brain damage.

Even if neither prenatal nor obstetric disturbances exist, a child may still contract cerebral palsy through certain accidental situations. An injury to the head in infancy, as might be sustained by a fall from a height, can result in a subdural hematoma with consequent sufficient damage to the brain to produce the clinical picture of cerebral palsy.

Certain diseases contracted during childhood, such as post-measles encephalitis, at times leave a child with typical cerebral palsy. Severe childhood diseases during which the temperature is high, or even out of control, for prolonged periods sometimes cause brain damage.

The treatment of anterior poliomyelitis can be divided into that which is administered during the acute stage and that which is performed later for rehabilitation. In the acute stage one may use either the so-called orthodox method or the Kenny method. In the orthodox method the weakened extremities are supported in positions of rest by the use of either splints or casts. These *are removable so that physiotherapy can be administered as soon as the general* condition of the patient permits. The physiotherapy consists of the application of heat in various ways (including warm baths), massage, and also passive motion to the joints. Muscle re-education and exercises are then instituted.

Under the Kenny method, the following program is carried out. Hot packs are applied to relieve the pain of the muscles that are in spasm and to relax these muscles. Passive joint motion is instituted. Then as the general condition of the patient warrants it, a system of physiotherapy is started. It consists of teaching mental awareness of the "alienated" muscles and of pointing out the point at which the various muscles insert. Next, assistive motion is given, and the patient *begins to gain control over a muscle. "Substitution"* is not allowed, and attempts are made to prevent "incoordination." Eventually, passive stretching is used wherever tight muscles may be found.

It is well to realize that for about four months following the original attack the patient may make large strides in his improvement. After four months, improvement does occur, of course, but it is slower, and progressively less can be anticipated Many patients continue to improve for even one to two years following the acute stage of the disease. However, 70 per cent of the return of muscle power which might be going to occur will have occurred within the first three or four months following the onset of the disease.

There remains, however, a group of patients who will need care different from that described. *Braces* to support weakened extremities may be needed, or operative procedures for reconstruction might be indicated. The specific procedures used for rehabilitation or for correction of deformities are described in the discussions of the foot, the knee, etc., earlier in this chapter. Certain general principles can be mentioned, however. If a deformity is due simply to tight, soft structures and has not been relieved by passive stretching during an adequate trial, operative lengthening can be used. For example, if there is an equinus deformity of the foot, lengthening of the Achilles tendon might be indicated. If, on the other hand, the deformity is due to muscle imbalance, tendon transference may be used; that is, the tendon of a powerful muscle can be transplanted to the point of the insertion of the paralyzed muscle to bring the part into muscle balance and thereby correct the deformity. Last, instead of tendon lengthening or tendon transference, operative procedures may be performed on the bone, either alone or in conjunction with tendon lengthening or transference. These procedures usually consist of an arthrodesis of one or several joints. At the time of the arthrodesis correction of the deformity is simultaneously carried out. The purpose of arthrodesis is not only correction *of the deformity, but also stabilization of an area where flail or uncontrollable* motion interferes with function. For example, let us suppose a flail-foot con-

involved. The gastrocnemius-soleus group is one. When this muscle group is affected, the foot has a tendency to be held in equinus. Passively, the foot can often be brought to normal position but immediately assumes the position of equinus when released. Therefore, if the child attempts to walk, he does so on tiptoe with a characteristic springy and almost clonic gait. The adductors and internal rotators of the thigh may be involved, causing the patient to walk with a "scissors" gait, one thigh rubbing the other instead of passing freely, as is normal. In the upper extremity the flexors of the wrist and hand are common ones to show the effect of the disease, as well as the adductors and internal rotators of the shoulder; that is, the entire upper extremity may be held in adduction and internal rotation at the shoulder, with flexion of the elbow and the hand and wrist tightly flexed, with the fingers clenched. In spastic paralysis, then, the involved muscles are receiving too many nervous impulses. Even if the opposing muscles are normal in strength, deformities and locomotor disabilities are present.

Instead of spastic muscles, patients with cerebral palsy may exhibit athetosis. In this state incessant, uncontrollable writhing motions are present. Partial deafness and speech defects are especially prone to occur in this condition.

The mixed type is the one in which both spastic muscles and athetoid movements are combined. It is possible to find gradations from patients with apparent true spastic paralysis, those with slight athetosis, those with spastic paralysis and athetosis about equally prevalent, and finally those with apparent true athetosis.

In ataxic cerebral palsy the sense of balance is either partially or completely lost. Disturbances of control of the eye motions are likely to occur.

Treatment for cerebral palsy, to be anywhere near complete, must consist of a program, and the problems are many. The program is best carried out at a cerebral palsy training center. If such a facility is not readily available, the family doctor can be of special service to the parents and the patient by undertaking as many of the different lines of therapy as possible. At a training center the child receives physical therapy, occupational therapy, speech therapy, special methods of didactic teaching, and socialization. In association with this program, special attention is given the parents in order that they may better adjust to an admittedly difficult situation and be of help in the treatment program.

Specifically, the physical therapist's efforts are directed at aiding the patient to achieve balance, during both sitting and standing (Fig. 50) and to walk with a reciprocal gait in a heel-to-toe pattern. The physical therapist does this by stretching the tightened areas. He stretches the Achilles tendon by repeated dorsiflexion of the foot (Fig. 51), taking care to move the *entire* foot en bloc, with the sole protected in order not to produce a rocker-bottom foot. The tight hamstring muscles behind the knee are stretched by repeated passive straight leg raising. The adductors of the thigh are stretched by repeatedly spreading the legs.

The patient is also taught a reciprocal gait by the physical therapist. The child is placed on a plint in a supine position. One leg is flexed onto the abdomen;

Regardless of the fact that cerebral palsy can arise from a number of unrelated causes, the disturbance can be classified from the general picture of the deficiencies exhibited by the children afflicted by the condition. It should be obvious that the muscle functions can be affected, that the special senses such as speech, balance, sight, and hearing may be disturbed or destroyed, that the intelligence may be altered, and that the personality may be unusual when compared to normal standards. Cerebral palsy can be divided into four types: (1) true spastic paralysis, (2) true athetosis, (3) mixed, and (4) ataxia. Other classifications are, of course, possible. (Fig. 49.)

BASIC CLINICAL TYPES AND CHARACTERISTICS IN CEREBRAL PALSY

	TYPE	BASIC CLINICAL CHARACTERISTICS
1	Spasticity	Increased resistance to manipulation, stretch reflex; hyperactive deep tendon reflexes, clonus, tendency to contracture deformities, lower extremities often more involved than uppers
2	Athetosis	Involuntary and incoordinated motions without conscious control, normal reflexes when in relaxed state; upper extremities often more involved than lowers
3.	Ataxia	Disturbance of autonomic balance, nystagmus, adiadochokinesis, difficulty in concentrating vision on a fixed field, normal tendon reflexes
4	Rigidity	"Lead pipe" resiliency of involved member, tendency to maintain position of extension; absent stretch reflex; near normal tendon reflexes
5.	Tremor	*Intention*-tremor contractions occur only with attempted motions, *nonintention*-tremor contractions are present constantly, no hyperactivity of tendon reflexes

EXTENT OF INVOLVEMENT

DESCRIPTIVE TERM	EXTENT OF INVOLVEMENT
Quadriplegia or tetraplegia	All four limbs
Hemiplegia	One side of body
Triplegia	Hemiplegia plus one limb of opposite side
Diplegia	Like parts on each side of body
Paraplegia	Both legs
Monoplegia	A single limb or part of body

Fig. 49.—Diagnosis cerebral palsy. (From Larson, C. B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

True spastic paralysis is a disturbance in which the lower motor centers of the brain and spinal cord can no longer be controlled by the higher motor centers because of damage to the latter. Hence, certain muscles of the body are in a state of increased tone. Excitement on the part of the patient or disturbing environmental factors increase the tightness of the affected muscles. Therefore, motor performance is usually worse if the patient feels he is being observed, if a stranger is present, etc. Certain muscle groups are commonly

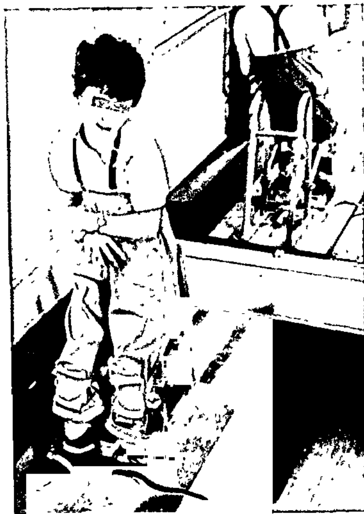


Fig. 50 —Patient with cerebral palsy in stabilizer to achieve standing balance.

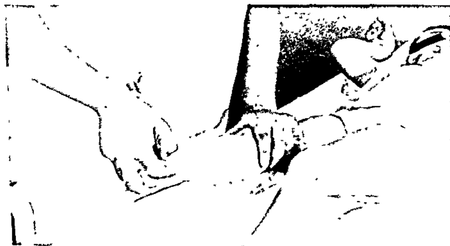


Fig 51 —Stretching the Achilles tendon. Note that the knee is kept in extension and that the entire sole of the foot bears the pressure (not simply the forefoot).

then, as the therapist brings the extremity into normal position, he simultaneously flexes the other extremity onto the abdomen. This exercise is ordinarily accompanied by a song or rhythmic music.

Standing balance is achieved by placing the patient in stabilizers (Fig. 50), which essentially are small platforms with attachments fitted onto the child's legs which aid him in assuming and maintaining the upright posture.

The patient's attempts at walking are made between the parallel bars which are constructed to prevent him from "scissoring." (Fig. 52.)

In addition to the methods of treatment described (stretching, reciprocation, standing balance, and gait training), special braces to aid ambulation and night braces are used. The night braces are usually adjustable so that progressively more correction of the tightened deformities can be gained.

If no physical therapist is available to carry out a program similar to the one just outlined, the family doctor should teach the parents how to perform such procedures.

The occupational therapist has as his duties the improvement of the hand and arm function and the teaching of self-care, such as eating (Fig. 53), dressing, undressing (Fig. 54), etc. In general, grasp and release of the hand are taught (Figs. 55 to 57) first by the use of large objects and then by the use of progressively smaller ones until the patient is able, for example, to string very small beads with a needle and thread. Pronation and supination of the forearm are taught through the use of games requiring these specific activities. Finger painting is engaged in to achieve general gross activities of the arm as a whole. By using toy shoes with large lacings the patient learns how to lace and tie his own shoes. (Fig. 58.) Specially constructed spoons with large, bulky handles to afford easier grasp are helpful in teaching a child to feed himself.

Again, if no occupational therapist is available, the family doctor can help by advising the type of activities just outlined.

Speech therapy is extremely specialized. The patient is taught first to develop an ability to exhale in a controlled fashion. (Figs. 59 to 61.) This can be done by having him blow a feather at first, and later to blow up a balloon. Still later the patient is taught to inhale deeply and then to attempt to count during exhalation He constantly trys to count higher in order to develop a more sustained capacity. The vowel sounds are taught with the patient in front of a mirror so that he may see his own lips and tongue and attempt to control their positionings. Individual words are then attempted, short phrases are tried next, and eventually sentences are attempted.

Didactic teaching of these children is best performed by a special teacher. (Fig. 62.) The teacher must realize that these children may have a short attention span, and she should attempt to develop the attention span. Retention of a fact may at first be poor, and therefore constant, sympathetic drilling upon a subject will be necessary. It is better that the daily life of these children be extremely orderly and predictable Any unforseen occurrence disturbs them. Therefore, the teacher should do the same thing at the same time each day. Simple childhood picture stories, such as *Little Red Riding Hood* or *The Three*

(*Text continued on page 120.*)

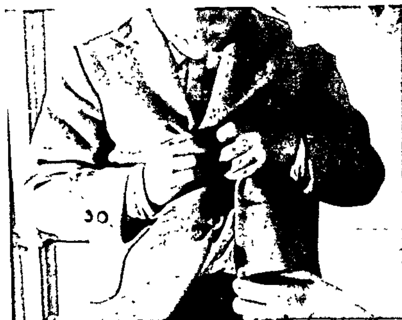


Fig. 54.—Therapist teaching a patient with cerebral palsy to button and unbutton clothing.

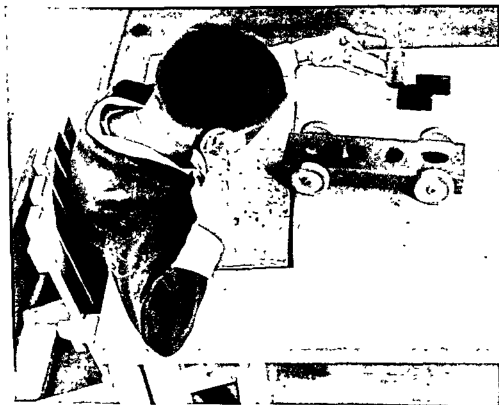


Fig. 55.—Patient with cerebral palsy learning grasp. Note that a toy is used to stimulate interest and that the object is large

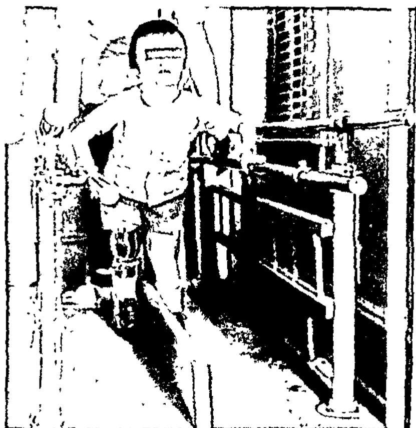


Fig. 52.—Patient with cerebral palsy learning reciprocal gait in the parallel bars. Note the center piece to prevent "scissoring."



Fig. 53.—Therapist teaching a patient with cerebral palsy to drink through a straw.



Fig. 58 —Patient with cerebral palsy using a large model requiring, in general, the same type of movements as are needed to lace the shoes.



Fig 59 —Speech therapist developing the ability in a patient with cerebral palsy to exhale by blowing on a horn

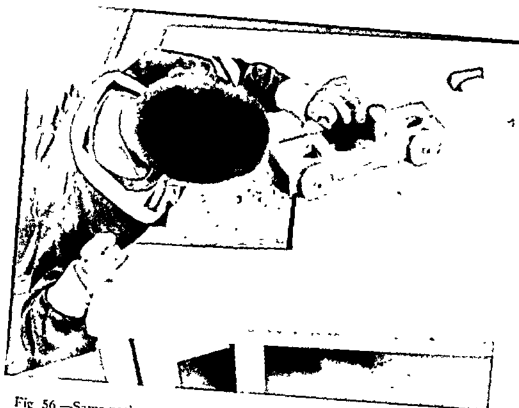


Fig 56 —Same patient as in Fig 55 in the process of just releasing an object.

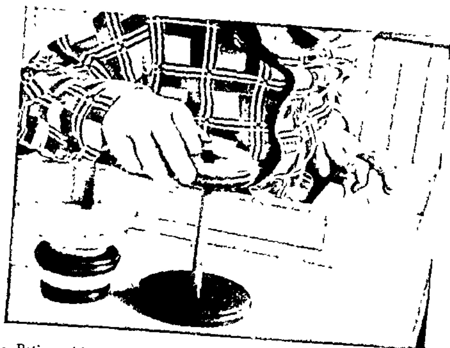


Fig 57.—Patient with [illegible]
Later smaller [illegible]
develop his ab[illegible]

[illegible]



Fig. 60.—Speech therapist using a combination of pictures and lip reading to aid speech in a deaf athetoid child

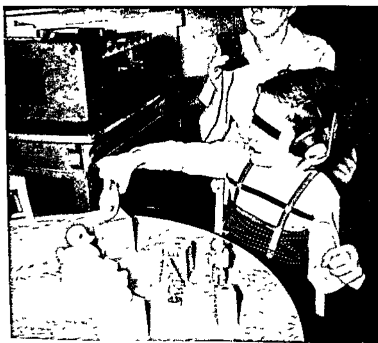


Fig 61.—Speech therapist using the Trainear to give instructions to a child with cerebral palsy.

Bears, are used in order to teach colors, numbers of objects, and the nature of activities, such as running, climbing, etc. Didactic teaching should be modified to fit the capabilities of each child, and teaching them is a special, slow, tedious job requiring unusual patience and understanding.

Socialization is of paramount importance to children afflicted with cerebral palsy. They have frequently been relegated to some secluded spot of the home where they get a minimum of contact with other human beings and where they have the least opportunity to learn through experience. In bringing a group of such youngsters together, each learns that he is not the only one with a problem. (Fig. 63.) Each learns to do what one of the others can do (Fig. 64.), and each learns to compete with others on a handicapped level rather than with an average child. Furthermore, group activity makes the child less dependent on his parents. After such a group has become well adjusted to one another, the group as a whole can be brought into contact with a large group of normal children. For example, the afflicted children as a group may be taken to an amusement park. Later, the child with cerebral palsy may, by himself, enter into contact with a small group of normal children.

The physician may advise a program similar to the one just discussed, even in the absence of an established training center.

Special attention is directed toward the parents of children with cerebral palsy, because the parents suffer from a specific group of psychic upsets and because they can aid a great deal in the rehabilitation of the child. In general terms, the parents are likely to believe that they are at fault and feel guilty. They may look upon the situation as one of special punishment for them. They are inclined to believe that no other parents ever had so difficult a problem.

In order to counteract these misconceptions, it is well to gather a group of these parents together and plan a program of meetings During these meetings the parents will learn from one another answers to many details in the management of the specific problems they encounter with their children. They learn that there are other parents whose problems may be worse than their own, and they learn to understand their own. They gain an understanding of some of the medical background and etiology of their child's disturbance. They have an opportunity for free-and-easy question-and-answer periods with the doctor.

The doctor should not hesitate to meet with the parents and give help by answering their questions. The parents will ask the cause of the disturbance, and they can in general understand that brain damage is the basis of the difficulty. They will ask if they were in any way at fault or to blame The doctor can ease their minds by reassuring them that the condition resulted from accidents over which they could have had no control. The parents will wish to know whether their child will ever be "cured" or "normal" It is well to explain that no such happy outcome can be anticipated but that the child's condition can probably be improved. It is well to warn that no good method is available to predict what improvement a given child will obtain, but it should also be emphasized that every effort will be made to help the child. Sometimes the parent will complain that the child is abnormally dependent upon either the

mother or the father and screams if the favorite parent leaves the room. The physician, realizing that dependency may prevent progress, may advise that another relative be introduced into the room everyday and that shortly thereafter the parent should leave the room for increasingly longer periods. Sooner or later the parent should leave the house while the child remains in the care of a particular relative. Finally even a strange baby sitter can be introduced. The parents may ask whether they should dress and undress the child or allow the child to do this. Even at the expense of considerable time, the parent should allow and even encourage the child to do more and more for himself. Parents many times are apprehensive about allowing the child to attempt independent walking for fear he will fall and damage himself further. The parents should



Fig 64.—Two children with cerebral palsy at play.

be urged to allow the child the most activity of which he is capable Parents will sometimes mislead themselves with regard to their child's mental ability simply because he knows a list of radio or television programs It should be pointed out that such an activity really has no special hopeful significance. The parents may ask advice about the sleeping pattern, since some of the patients have bizarre habits. They should be advised not to allow too much sleep during the day, and medication for a short period can be used to establish a better sleeping pattern at night. The doctor who is willing to spend the time at a parents' meeting can fill a crying need in this difficult problem.

From the standpoint of reconstructive surgical procedures, certain generalities can be considered. If, for example, physical therapy has failed to stretch a contracted muscle, tendon lengthening may be performed Lengthening of the Achilles tendon is one of the common procedures used in such circumstances. A second general way of approaching the problem is by neurectomy of the nerve



Fig. 62 — Didactic teaching using pictures to teach colors, number of objects, size and shape of objects, stories, etc.



Fig. 63 —Children with cerebral palsy at play. They learn from one another.

Chapter Two

General Features of Orthopedic Disturbances in the Adult

There is no clear-cut division between the orthopedic problems in childhood and those in adulthood. Nevertheless, in considering orthopedic disturbances in the adult, the physician's thinking should be directed more toward the processes of trauma, degenerative changes, and those conditions resulting from disturbances which had their origin during infancy and childhood and which have been modified by the passing of considerable time. Since trauma will be a major consideration, it seems worth while to present certain general principles of orthopedic examination and of management of fractures. In addition some of the possible complications occurring in a fracture, together with some emergency measures which might be helpful in the acute traumatic situation, are discussed. Those instances in which the treatment of trauma in the child presents special considerations will be emphasized.

ORTHOPEDIC EXAMINATION

Orthopedics is concerned with the alterations in function of the neck, the back, and the upper and lower extremities A specialized orthopedic examination is used for each anatomic part and each condition. However, certain general principles of examination are applicable in most conditions. A fact that should be remembered at all times is that the affected extremity can almost always be compared with its replica on the other side. This makes deviations from normal in the individual patient easier to detect. The comparison can be made in several of the observations, including the range of motion, muscle power, vascularity reflexes, sensitivity, muscle atrophy, leg-length discrepancies, etc.

Inspection of the involved area is a valuable part of the orthopedic examination and should include observation of swelling, deformity, atrophy of the muscles, and, in particular, the color of the area From inspection alone one may obtain a great deal of information which will be helpful in making the correct diagnosis

It is important in the general examination to note the range of motion of the joints, both passive and active, and to compare the range of a given joint

to the spastic muscle; that is, the nerve to the involved muscle is exposed and one or more of its branches are severed. Thus the number of impulses reaching the muscle are reduced, and therefore the overactive muscle is relaxed. Neurectomy is commonly performed on branches to the gastrocnemius muscle to correct an equinus deformity and tiptoe gait. It has been often performed on the obturator nerve to relieve adduction of the thighs and correct the scissors gait. Neurectomy of branches of the median nerve has been performed to correct a pronation deformity of the forearm and flexion of the wrist and fingers.

In addition to tendon lengthening and neurectomy, arthrodesis is sometimes performed to correct a disabling deformity. The purpose of the operation is to place the extremity in a more serviceable position. For example, arthrodesis of the wrist in a cock-up position might allow better function of the fingers than if the wrist were to remain in the position of flexion. Some believe that arthrodesis should not be performed on patients with spastic paralysis because of the claim that a deformity will occur. We do not agree with such a stand.

Naturally, in addition to the procedures just described, operations which act as *adjuncts to such procedures may be employed. For example, a procedure* which releases the contracted soft tissues sometimes accompanies a tendon lengthening operation or a neurectomy.

It should be clear that cerebral palsy, with its various manifestations, is an important disturbance whose over-all management presents many difficulties. Some patients are so slightly affected that very little care is necessary. Others are so badly afflicted that, at present, custodial care seems to be the only solution Many need long-term hospitalization in special institutions equipped to provide schooling, occupational therapy, physical therapy, socialization, and surgical reconstruction.

It is well to keep in mind that, before operative procedures are performed, an evaluation of the child's intelligence should be undertaken. This is necessary in order that the patient not be pushed too hard in his schooling, etc., and that the surgeon may feel reasonably certain that his patient will be intelligent enough to use the reconstructed extremity to advantage. The specific operative procedures used are described in the discussions of each anatomic region, such as the foot, the knee, the hip, etc , earlier in this chapter.

vascular condition of a hand may lead to a diagnosis of reflex sympathetic dystrophy, and proper treatment by cervical sympathetic block may alleviate what otherwise might be a very mysterious pain in the hand.

The reflexes of an extremity should be checked routinely and compared with those of the normal extremity. A diminished or absent ankle jerk in a patient complaining of back pain may be the lead to the positive diagnosis of a ruptured nucleus pulposus which otherwise would have escaped detection. Progressive changes in the reflexes in a patient under close observation for back pain may be the warning of an impending paralysis of the legs due to a spinal cord tumor. The various reflex changes in conditions such as anterior poliomyelitis and cerebral palsy are to be considered in this category.

It is well during the examination of an extremity to test the skin for sensitivity to pin prick and to note any areas of diminution in sensitivity. Diminution of sensitivity may be useful in the diagnosis of ruptured nucleus pulposus and several other common orthopedic conditions.

The orthopedic examination frequently includes comparative measurements. For example, leg length is often measured in such widely varying conditions as congenital dislocation of the hip, congenital hemihypertrophy, malunited fracture of the hip, etc. Furthermore, circumferential measurements of the extremities are helpful in determining whether an area is the site of muscle atrophy.

Certain maneuvers are used to apply stress or strain to various parts. For example, an adduction force may be brought to bear on the lower leg at the knee in conjunction with an opposing abduction force to reveal either lateral stability or instability of the knee joint. Furthermore, such stresses are sometimes helpful in arriving at a diagnosis of a strain of the collateral ligament of a joint. Also stress is applied to a fracture site which should be healed to test it clinically for stability.

In summary, the orthopedic examination can be divided into three general categories. First, the comparison of the affected part with the normal to determine deviations in alignment of the bones or joints and to discover any loss in active or passive range of motion in the affected joint. Second, the investigation of the blood supply in the extremity. Third, the determination of the existing strength of the neuromuscular supply in the affected extremity.

MANAGEMENT OF FRACTURES

A fracture is a disruption of the continuity of the bone usually caused by a relatively severe trauma Fractures are divided into two main classes, simple and compound. Compound fractures are those in which there is a communication between the exterior and the fracture site. Compounding may occur "from within" or "from without." That is, if the fracture fragments have pierced the skin, causing the compound wound, it is "compounding from within." If some external object has lacerated the skin and overlying soft tissue down to the fracture site, "compounding from without" is said to exist. The following degrees of severity of a compound fracture may occur: (1) there may be a very small puncture; (2) the ends of the bone may protrude above the skin surface, with little or no loss of the soft tissue; (3) there may be a large, gaping wound, with

with that of the same joint on the other side. The following possibilities should be noted: (1) whether the joint is limited by a sudden stop, caused perhaps by impingement on the bone; (2) whether the limitation is due to soft tissue contracture; (3) whether the limitation is voluntary on the part of the patient to mislead the examiner deliberately; (4) whether the patient complains of pain upon motion of the joint; or (5) whether the limitation is due to involuntary muscle spasm.

An orthopedic examination should also include palpation of the involved area It should be emphasized that many patients feel that the doctor has not in fact examined them unless there has been a "laying on of hands." Palpation will indicate something about the nature of an area of swelling; that is, whether the swelling is due to edema, to a hematoma, to a cystic structure such as a ganglion, or to a malignant tumor. Furthermore, the examiner may determine the exact location of the difficulty by eliciting tenderness in a very specific area. Palpation reveals the presence or absence of crepitus Crepitus over the shaft of a bone may indicate a fracture. Over a bony prominence it may indicate an irritative lesion formed by the snapping or moving of the tendon or muscle over the bony prominence. Crepitus overlying a tendon may indicate tenosynovitis. The point is that palpation of the involved part will reveal much about the condition for which the patient seeks advice.

The testing of the muscle power of the involved part should be routine in an orthopedic examination. First, the active muscle power per se is observed. That is, the patient is requested to engage in active motion of the affected part while the examiner compares this motion with that of the opposite normal side. It may be that the patient is, for example, unable to dorsiflex the wrist or the ankle, to extend the knee completely, etc. After simple active motion has been observed, active resistive motion of the area can be carried out. In this maneuver the patient is requested to perform a given active motion while the examiner resists the attempt The examiner can judge the strength of the muscle power surrounding the given joint by comparing the power of the joint receiving the active resistive motion with that of the opposite normal side. Active resistive motion is not only a means of measuring muscle power. It is sometimes used to discover a disturbance which might be quite removed from the area being tested. For example, in lateral epicondylitis of the elbow active resistive dorsiflexion of the wrist and hand produces pain in the region of the lateral epicondyle of the humerus and indicates a disturbance of the elbow.

The vascularity of the extremity should be observed to note any color change in the nail beds or skin and compared with the opposite normal side. In addition, it is well to determine whether there is an increase in the sweating and a decrease in the temperature of the involved part Furthermore, the main arteries to the area, such as the radial pulse, the dorsalis pedis pulse, the posterior tibialis pulse, etc., should be palpated The vascular condition of an area may give the clue to the diagnosis That is, pain in the feet may be due to arteriosclerosis or Buerger's disease rather than to pronation The vascular supply distal to a fracture may be the deciding factor in whether closed reduction, open reduction, sympathetic block, or even amputation will be the treatment of choice. The

metabolic or unknown origin, which affect and weaken the structure of the bone, can be the basis for a pathologic fracture. Examples of such conditions are metastatic carcinoma of the breast and lung, giant cell tumor, osteolytic sarcoma senile osteoporosis, hyperparathyroidism, Paget's disease, etc.

Diagnosis of Fractures

Diagnosis of a fracture can be made on the basis of several different pieces of evidence. It is well to go as far as is reasonable in deciding whether or not a fracture exists before taking roentgenograms. The history of how the injury was sustained should be obtained. It is true that events happen so rapidly that the patient cannot always furnish a reliable history of the mechanism of the injury. The physician should weigh in his own mind whether the described trauma is adequate to produce a fracture. Sometimes a pathologic fracture can be suspected because of the apparent *inadequacy* of the reported violence to cause a fracture in healthy bone. Clinical examination of the injured part is important. Inspection may reveal a striking deformity. Local swelling and ecchymosis may indicate an underlying fracture, but not necessarily. Abnormal mobility at the site of the injury is often present. Crepitus, a grating sensation to palpation, may be obtained by moving one fracture fragment against the other. However, it is not ordinarily necessary to elicit crepitus, and since it is so painful, it usually is not used as a test. Gentle palpation of the injured area may elicit point tenderness over the fracture. Roentgenograms are taken in order to confirm the clinical diagnosis and to give information as to the exact type and location of the fracture. It should be emphasized that the clinical examination and opinion should not be abandoned simply because diagnosis from roentgenograms seems to be easier and more reliable.

Therefore, the diagnosis of a fracture is based on the following: (1) a history of adequate trauma, (2) pain, local swelling, and ecchymosis, (3) deformity, (4) abnormal mobility, (5) crepitus, (6) point tenderness, and (7) roentgenograms.

Fundamentals of Fracture Treatment

The objectives of any method of treatment of a fracture are approximation of the ends of the bone, alignment of the bone ends as normally as possible, and immobilization of the fracture site until healing has taken place. To accomplish these ends several fundamentals should be kept in mind. The exposition of these principles is difficult without giving the impression that a great many seemingly unrelated facts are being considered. However, the management of specific fractures (to be discussed later) will seem considerably more reasonable (rather than arbitrary) if the practitioner has a knowledge of the following general fundamentals. An understanding of these principles should enable him to reason out an acceptable program of treatment for a given fracture, rather than attempting to recall the exact method by "brute memory."

A fracture is sustained as a result of a given set of forces which many times bring about characteristic displacement and deformity. The medical student frequently attempts to remember the exact steps of the manipulations which

loss of skin, muscle, and even bony substance in the more severe types. Simple fractures are those in which there is no communication with the exterior. The term in no way relates to the complexity of the injury to the bone. Within these two classes many types of fractures are possible.

Types of Fracture

A *greenstick fracture* is an incomplete fracture in which one cortex is *broken* and the opposite cortex is *bent*. The bend is on the concave side. It is usually a simple fracture.

An *infraction* is essentially the reverse of a greenstick fracture; that is, the cortex is simply bent on the convex side, while the cortex on the concavity is buckled. The greenstick fracture and the infraction usually occur in children. The reason is easily understood. The bones in a child are more flexible than in an adult, and hence a bend rather than a complete break in continuity is more likely. The greenstick fracture takes its name, of course, from its similarity to the manner in which a fresh (green) stick of wood breaks.

Compounding from within is almost an impossibility in the greenstick fracture and the infraction because it is difficult for an incomplete fracture to pierce the skin. However, compounding from without is a possibility because of associated lacerations. Such occurrences are unusual.

An *avulsion fracture* is one in which a fragment of bone has been torn loose by a ligament or a tendon. It is usually simple.

An *epiphyseal separation* results from a fracture through the cartilaginous epiphyseal plate. Compounding is not common.

A *comminuted fracture* is one in which there are more than the two main bone fragments present, that is, there is a large central bone fragment in addition to the two main fragments. Comminution is also applied to a fracture in which splintering and shattering of the bone has taken place, resulting at times in a great many small bone fragments in addition to the two main fragments. Comminuted fractures may be simple or compound.

An *intra-articular fracture* is one in which a joint or the articular cartilage of a joint is involved. In civilian practice intra-articular fractures are not often compound.

A *compression fracture* ordinarily occurs in the vertebral column. If the spine is subjected to a violence in flexion, one or more vertebral bodies may suffer compression fractures. The vertebral centrum is essentially crushed or "compressed" so that the height of the vertebral body is decreased. The compression most frequently involves the anterosuperior aspect of the centrum.

Oblique, spiral, and *transverse fractures* are self-descriptive terms.

Another general type is the *pathologic fracture.* This occurs because of some underlying defect or disease of the bone, and many times trauma of minimal severity is adequate to cause the fracture. For example, bone which has been partially destroyed by a metastatic carcinoma may be fractured easily by as simple a trauma as turning in bed. Bone which is the site of extensive osteoporosis due to a metabolic disturbance may be subject to pathologic fracture. Malignant and benign tumors of the bone, metastatic tumors, and diseases of

of the midshaft of the humerus can be treated by applying a cast which immobilizes not only the elbow joint, but also the shoulder joint. There are many exceptions to this principle.

The type of fracture often influences the method of treatment. If the fracture involves the shaft of a *single* long bone (for example, the humerus or the femur) and if the fracture is *oblique* (one bone fragment tends to override the other) because of the obliquity per se. Thus treatment of an oblique fracture of the shaft of the femur or the humerus is not so likely to be by a cast *alone* (primarily) as by some other method such as traction, whose main function is to prevent overriding of the fragments. Therefore, the principle to remember here is that *the fragments of an oblique fracture of a single long bone tend to override.*

The principle just discussed applies to a fracture of the forearm or lower leg also. Assume that the radius presents an oblique fracture. If the ulna is intact, overriding of the fragments is not likely since the intact ulna acts as an internal splint. On the other hand, if the ulna is not intact, then the oblique fracture of the radius acts analogously to an oblique fracture of the shaft of a single long bone. The same is true for the tibia and fibula. If the tibia is fractured and the fibula is intact, the two fragments are not likely to override. If both the tibia and fibula are fractured, overriding is common. It is apparent that *one bone may act as an internal splint for another and that if both bones of the forearm or the lower leg are fractured, the condition is analogous to a fracture of the shaft of a single long bone.*

In a transverse fracture of a single long bone the fragments tend to angulate but are not so prone to override unless one fragment has been completely displaced from the other. For example, if there is a transverse fracture of the shaft of a single long bone, such as the humerus, with end-to-end contact between the fragments, the fragments may angulate but will not override unless the end-to-end contact is lost. Of course, if the ends are completely displaced, the tendency of the fragments to override is just as likely as in an oblique fracture. The point is that in an oblique fracture, manipulation to achieve reduction and the application of a cast are likely to fail because there is no stability at the fracture site. Whereas, in a transverse fracture manipulative replacement and the application of a cast are likely to be successful.

The facts regarding an oblique or transverse fracture of a single long bone are especially applicable to the humerus, the femur, the radius if the ulna is also fractured, and the tibia if the fibula is also fractured.

In a badly comminuted fracture the tendency both to override and to angulate must be expected and managed.

It goes without saying, that unless a sufficient amount of one fragment is in contact with an adequate surface of the other fragment, healing may fail. It is not *necessary* to reduce every fracture anatomically. Generally, *at least one half of the fracture surface of one fragment must be in contact with at least one half of the fracture surface of the other fragment* for healing to be successful.

The bone edges at a fracture site are often sharp and jagged and frequently have injured the surrounding tissue. Consequently, a principle that should

are used to reduce a fracture. This is unnecessary. He needs only to reverse the forces which caused the deformity—a process which is usually easy to reason out if the position of the bone fragments is kept in mind. For example, in a fracture of the hip the involved extremity usually is shorter than the normal one, is held in external rotation, and is in a position of adduction. To reduce such a fracture, simply reverse the position of the deformity by exerting traction on the leg to overcome the shortening, by rotating the leg internally to overcome the external rotation, and by abducting the leg to counteract the adduction. Thus we have one of the principles in the treatment of a fracture. *In order to reduce a fracture by manipulation, apply in logical sequence forces designed to reverse the force and position of the deformity.*

Muscle pull is frequently an important consideration in both the position that the fracture ends assume and the position used in treatment. For example, in a fracture of both bones of the forearm *above* the insertion of the pronator teres the proximal fragments are in a certain degree of supination, since the main supinators are acting on the proximal fragments. The operator can control the distal fragments but not the proximal fragments, and he must position the controllable distal fragments to match the position of the uncontrollable proximal fragments Thus, we have another principle in the treatment of a fracture. That is, *the fragment which can be controlled should be positioned in alignment with the fragment which cannot be controlled.*

There is a tendency for the original deformity of the fracture to recur. *This tendency should be combatted.* It can be controlled by proper positioning of the extremity and by shaping the cast in such a manner as to prevent recurrence. For example, in a Colles' fracture (fracture of the distal radius with dorsal displacement of the distal fragment) there is a tendency for the distal fragment to slip back into the deformity of dorsal displacement. After reduction of the fracture, the hand and wrist are positioned in flexion to combat the tendency toward dorsal displacement. Next the cast is applied and molded over the hand and wrist in the flexed position, acting as a continuous force in preventing recurrence of the deformity.

Certain fractures which involve joint surfaces are called intra-articular fractures. If displacement of a fragment has occurred, it is obvious that several possible conditions may ensue A fragment may block the motion of the joint because of its position, or it may remain loose and free in the joint, acting as a source of recurrent locking, irritation, and progressive destruction of the joint. If the articular surface heals with appreciable incongruity, hypertrophic arthritis may develop and eventually become disabling. *Therefore, as a general principle, an intra-articular fracture requires excellent reduction by one means or another.*

A fracture in a child may at times involve the epiphyseal cartilage; that is, the epiphysis will constitute one fragment and the shaft the other. If the epiphysis (the growing center) is not replaced anatomically, continued growth will produce an even greater deformity. *As a general principle, a fracture through the epiphyseal plate, with displacement of the epiphysis, requires anatomic (or almost anatomic) reduction.*

In order to immobilize a fracture site adequately, it is ordinarily necessary to *immobilize the joints proximal and distal to the fracture.* For example, a fracture

8. One bone may act as an internal splint for another.
9. The fragments in a transverse fracture with end-to-end contact are not so prone to override as they are to angulate.
10. At least one half of the fracture surface of one fragment should be in contact with at least one half of the fracture surface of the other fragment for healing to be successful.
11. The extremity should be examined to detect nerve lesions and to estimate the adequacy of the blood supply distal to the fracture.
12. Prereduction and postreduction roentgenograms are taken routinely.
13. Internal fixation is not a substitute for bone healing.
14. No treatment other than first aid and emergency splinting should be given until after the roentgenograms have been taken.

Specific Methods of Fracture Treatment

Now we consider the available methods in the treatment of the fracture.

There are five general methods: (1) closed reduction with splints and/or casts, (2) traction, (3) open reduction, with or without internal fixation, (4) external splinting with transfixing pins, and (5) intramedullary fixation with special pins.

Splints and/or Casts.—The purpose of a splint or a cast is simply to hold the bone in a given position until union has occurred. Their main function is *immobilization.* There are several types of cast in common use, some of which will be described.

The shoulder spica is a cast frequently used in the treatment of a fracture of the humerus. It starts at the iliac crest, encloses the trunk, passes over the shoulder of the involved side (leaving the opposite shoulder free), continues down over the humerus (site of the injury) with the humerus at the desired degree of abduction, and extends below the elbow, immobilizing the forearm and supporting the wrist and the hand. In keeping with one of the previoulsy discussed principles, this cast immobilizes the joint proximal to the injury and the joint distal to the fracture To immobilize the shoulder, the cast must encircle the trunk and take its support from the iliac crest.

The hip spica, used in the treatment of a fracture of the femur, can be either a single hip spica or a double hip spica. The single hip spica starts at the lower costal cage, passes down over the abdomen, immobilizes the hip joint, thigh, and knee on the involved side, and continues down the entire leg and over the foot. The double hip spica extends down both lower extremities to the toes.

A sugar-tongs cast is used principally in the treatment of a fracture of the distal radius (Colles' fracture). It is a single splint of plaster and, while wet, is laid on the dorsum of the forearm, molded around the posterior aspect of the elbow, and carried along the volar aspect of the forearm. Thus, the cast is in the form of a long "U", simulating the tongs used to pick up a lump of sugar. The cast extends to, but no farther than, the metacarpophalangeal joint on both the dorsal and volar aspects If it extends beyond these joints, stiffening of the fingers might result.

always be applied is *careful examination for the presence of nerve lesions and for the adequacy of the blood supply distal to the fracture.* This cannot be overemphasized, and more will be said later regarding it.

An extension of this principle is that splints should be applied to a fracture immediately, if only as a temporary or first-aid measure. This prevents the fracture from doing more damage to the soft tissues, nerves, and blood vessels, and makes the patient more comfortable.

A word should be said about the use of x-ray pictures. It is good practice to obtain a roentgenogram of any fracture or dislocation before anything more than emergency treatment is administered. These roentgenograms are the so-called prereduction films. After definitive treatment has been carried out, postreduction roentgenograms are taken. The practice of obtaining prereduction and postreduction roentgenograms is routine and will not be mentioned in the treatment for each individual fracture discussed. If a fracture is treated by traction, it is customary to take reontgenograms at intervals in order to check position, to detect any needed changes in alignment, and to note the development of callus and healing. Furthermore, before a cast is removed permanently, a bivalve should be cut in order to test the fracture site for stability clinically. A roentgenogram is obtained while the extremity is out of the cast. If healing is good clinically (as indicated by the stability of the fracture site) and the roentgenograms show callus, with obliteration of the fracture line, the cast is left off. If there is motion at the fracture site, the condition is considered to be delayed union or nonunion. The procedure to follow under such circumstances will be discussed later.

Certain fractures are managed by open reduction and the application of various types of internal fixation, such as metal plates, screws, wires, heavy silk, etc. Internal fixation tends to give the erroneous impression that adequate stability is gained thereby. *As a principle it should be remembered that internal fixation is no substitute for bone healing* Casts and other types of immobilization are just as sorely needed with internal fixation as without it. The purpose of internal fixation is simply to hold the fragments in the desired position until healing takes place.

In summary, there are fourteen fundamental principles of treatment as follows:

1. A fracture is reduced by manipulation by applying, in logical sequence, forces designed to reverse the force and position of the deformity.
2. *The fragment which can be controlled should be positioned in alignment* with the fragment which cannot be controlled.
3. The tendency for the original deformity of the fracture to recur should be combatted by proper positioning of the extremity and by shaping the cast to prevent recurrence.
4. An intra-articular fracture requires excellent reduction.
5. A fracture through the epiphyseal plate with displacement of the epiphysis requires excellent reduction
6. The joints proximal and distal to, the fracture should be immobilized.
7. The fragments in an oblique fracture of a single long bone tend to override.

8. One bone may act as an internal splint for another.
9. The fragments in a transverse fracture with end-to-end contact are not so prone to override as they are to angulate.
10. At least one half of the fracture surface of one fragment should be in contact with at least one half of the fracture surface of the other fragment for healing to be successful.
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A hanging cast is used at times in the treatment of certain fractures of the humerus. Its purpose is to exert traction on the shaft of the humerus by means of the weight of the cast, which hangs freely in the air. It is applied in a circular manner from the upper portion of the arm downward over the elbow, which is at right angles, and over the forearm. The portion over the forearm is made especially thick, with a loop incorporated into it. The cast is suspended by a sling which passes through the loop.

A cast is used in the following specific circumstances*: (1) if no displacement of fragments is present or seems likely to occur, (2) following reduction if the fracture is such that manipulation can reduce the displacement, (3) sometimes following traction which has been used during the first four to six weeks in order to allow healing to begin, and (4) following open reduction with internal fixation. Internal fixation is no real substitute for a cast. The function of internal fixation is to aid in holding the reduction, but the strength of the material is usually not adequate for this without a cast.

Traction.—Traction is a method of applying a constant force to the bone by a mechanical means It is used mainly to distract the bone and to prevent the fragments from overriding. Its ability to immobilize, although present, is not so great as that of the other four methods of treatment.

Traction may be either skeletal or adhesive-skin. There are various types of *skeletal traction. A wire may be inserted through and through the olecranon* and weights attached to it. By the force of the weights, skeletal traction is exerted on the shaft of the humerus. Likewise a wire may be inserted through and through the tibia or calcaneus, and the force of weights attached to it will exert traction on the shaft of the tibia.

Traction is used in several circumstances. (1) It is used to align a fracture which probably would not *remain* reduced even after manipulative reduction. For example, it might be perfectly feasible to reduce an oblique fracture of the shaft of a single long bone by manipulation. However, the bone fragments would perhaps override or angulate following the reduction simply because of the obliquity per se. (2) Traction is often used if a fracture is so badly comminuted that not sufficient stability can be obtained to justify either application of a cast or alignment by open reduction. (3) If the condition of the patient is poor because of age or the complications of age or because of shock due to trauma, traction is possibly the quickest and least disturbing procedure to follow. Traction in the aged should not be used for long periods of time if it can be avoided, because elderly people often develop fatal complications if immobilization is continued. (4) Should the fracture be intra-articular and too badly comminuted to be managed by operative procedure, traction probably offers the best chance to restore a fairly normal contour to the joint.

Open Reduction.—Open reduction is the procedure whereby a fracture is operatively exposed and reduction accomplished under direct vision. After the reduction the bone position can be maintained by one type or another of internal fixation. If the fracture is oblique, several screws may be inserted directly across the fracture from one fragment to the other and should entirely

*Exceptions can, of course, be found to these very broad statements.

penetrate both cortices. If the fracture is transverse, a metal plate affixed by screws to each fragment is used to bridge the site. Sometimes wire sutures and other times heavy silk ones are used to maintain reduction. After closure of the operative wound, a cast is applied until healing of the bone takes place. It is to be remembered that internal fixation is used simply to maintain reduction and is in no way a substitute for bone healing (therefore, the necessity for the cast).

Open reduction is used in various circumstances. (1) If a fracture occurs in such a way that no conceivable manipulation can replace the fragments, open reduction is indicated. An avulsion fracture of the epiphysis of the medial epicondyle of the humerus, with complete displacement of the fragment, is an example of a fracture frequently requiring open reduction. (2) If the fracture involves a joint in such a way that an appreciable incongruity of the joint surface is to be expected later, open reduction is indicated. (3) Occasionally a fracture occurring through an epiphyseal line cannot be reduced by manipulation. Inasmuch as the growing center will eventually produce a bad deformity unless respositioned in very good alignment, open reduction should be used if closed reduction fails. (4) Operative reduction is used if difficulty is experienced in procuring satisfactory alignment by traction for some reason, such as the interposition of soft parts. (5) In fractures in which a nerve is believed to be caught between the bone ends, the fracture site should be exposed and reduced, and the nerve should be explored. (6) A compound fracture requires débridement of the wound; in such cases the operator usually proceeds with open reduction.

External Splinting With Transfixing Pins.—External splinting with transfixing pins is accomplished by the use of one or another of various splints. Essentially, two metal pins are passed through the skin and soft tissue and drilled through both cortices of one fragment. Two similar pins are affixed in a like manner through the other fragment. Reduction is then carried out either by manipulation or operation. Following the reduction, one or more metal bars are used to fixate all four pins together externally. The purpose of this procedure is to immobilize the fracture site but not the joint above and the joint below the fracture. The procedure prevents joint stiffness which may result later if a cast has been used. The object of using transfixing pins with external fixation is to avoid the incapacity attendant upon the use of a large, cumbersome cast (for example, the hip spica) and the danger in immobilization of an elderly or debilitated patient. The method allows early ambulation and use of the extremity in a patient who, if treated by conventional methods, would be severely disabled for a prolonged period. External splinting with transfixing pins has a great many disadvantages. Drainage around the pins, small sequestra in the shape of rings around the pins (the so-called ring sequestra), and cellulitis of the surrounding soft tissue are among the disadvantages which have caused many to discard this mode of fracture treatment entirely. We prefer other methods of treatment.

Another very useful method of treatment which embodies the principle of transfixing pins and external fixation is the incorporation of Kirschner wires into a cast. A Kirschner wire is inserted transversely through and through the

proximal bone fragment and another is passed similarly through the distal fragment. Reduction by manipulation is then done, and the reduced fragments are held in position while a cast incorporating the protruding ends of the wires is applied. Hence the fragments are held firmly by the wires, and the bones will not slip or override. This procedure avoids the disadvantages of the first method, in which larger pins are drilled into the bone.

Intramedullary Fixation With Special Pins.—The general principle of intramedullary pinning is the insertion of a long, metal pin down the length of the hollow medullary canal of the long bone. A technique has been developed which is used mainly in the management of a fracture of the shaft of the long bone. A rather long, reasonably heavy, and fairly rigid metal pin is inserted throughout the length of the medullary canal and across the fracture site after reduction. The advantages of the method are that it allows early mobilization of the patient, early movement of the adjacent joints, and close approximation of the fracture surfaces during healing (instead of being held apart as might happen with the use of a bone plate and screws). Only those surgeons especially experienced in this technique should perform the operation.

Occasionally this same principle can be used in the shaft of a small bone, such as the metacarpal, and a Kirschner wire is inserted into the medullary canal.

Definitive Treatment of Compound Fractures

A compound fracture, as stated previously, is one in which the fracture communicates with the exterior through a wound. Fundamentally the significance of compounding is that the fracture site has been contaminated by an organism and is subject to infection. Compounding may take place from within or from without, depending upon whether the bone has pierced the skin or whether some external object has lacerated the overlying tissue down to the fracture site. The severity of the compounding is variable, at times being only a small puncture wound and at other times consisting of avulsion of large areas of skin, the loss of muscle substance, and even the loss of bone.

There are various ways in which a compound fracture can be managed. Only one method which has seemed satisfactory will be presented here.

The physician should keep in mind that he is treating the patient as a whole and not simply for a compound fracture. Evidence of bleeding is sought first; if present, it is stopped immediately—by tourniquet, if necessary. Attention is then directed to the patient's general condition. A compound fracture is often accompanied by severe trauma, and therefore frequently the patient is in shock or about to go into shock. It is well to start a blood transfusion as treatment for shock if it is present or as prophylaxis against shock if it has not already occurred. Next, the patient should be examined for injury to the head, chest, and abdomen. Last, attention is directed to the compound fracture.

Objects grossly contaminating the wound, such as bits of clothing, leaves, twigs, etc., should be removed, and a sterile dressing should be applied. Such treatment is of a temporary nature to prevent unduly long contact of contaminating material with the wound.

The fracture site is splinted adequately in order to prevent further damage to the surrounding soft parts and to afford the patient some relief from the pain. Incidentally, splinting aids in preventing or combatting shock.

An adequate dose of tetanus antitoxin or mixed antitoxin is administered to those patients who have not been previously immunized against tetanus. A booster dose of toxoid is given to those who have been previously immunized.

Sedation for pain can be given, provided there is no suspicion of an accompanying intracranial or abdominal lesion.

If the general condition of the patient is satisfactory, a roentgenogram is taken, using portable equipment to avoid disturbing the patient. He is then brought to the operating room. Under the usual sterile operating room technique the wound and the surrounding area are carefully cleaned. Copious irrigation of the wound is carried out. The wound is débrided thoroughly; that is, the skin edges and all badly traumatized or obviously necrotic tissue is excised. Reduction of the fracture is carried out under direct vision. Many orthopedists object to the practice of leaving the nonabsorbable material (screws, plates, wire, etc.) such as is used in internal fixation in a compound wound. However, it can be done safely provided the conditions are favorable for primary closure of the wound. (See discussion to follow.) The question arises as to whether the wound should be sutured completely (primary closure), whether it should be left open and allowed to heal by itself (secondary intention), or whether it should be sutured at a later date (delayed closure). In civilian practice (a compound fracture as a result of a war injury is managed differently) the time element is of importance. If definitive treatment of the wound has been started within six to eight hours after the injury, the wound is considered *contaminated* only. If much over eight hours has elapsed since the injury, the wound is considered not only contaminated, but also *infected*. Many surgeons close the wound primarily if the time interval is satisfactory (that is, less than six hours after injury). It is under such conditions that the metallic internal fixation materials can be left in the wound without harm. The length of time after injury is not the only factor influencing the decision to effect a primary closure. The amount of damaged soft tissue, the adequacy of the blood supply, the extent of avulsed skin, and the number and nature of the contaminating objects within the wound are all influencing factors. Judgment should be exercised at all times. For example, if there is a large mass of crushed and contused muscle of questionable viability, primary closure may be unwise even if the treatment is carried out within six to eight hours after injury. If the blood supply to the area is adequate to ensure viability, but if the margin of safety appears to be not too great, it is perhaps best not to effect a primary closure despite the proper time element. Again, if the wound is extensively contaminated by objects of high bacterial count, it is better to allow healing by secondary intention or to do a delayed closure.

In essence, the question is whether, in the opinion of the operator, the condition of the wound will produce infection. If infection is unlikely, use a primary suture; if it is likely, allow healing by secondary intention or use delayed closure.

If the wound has been left open, it is usually loosely packed with petrolatum gauze, and care is taken not to block egress of the exudate from the wound.

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opens a wedge on the lateral aspect (open-wedge osteotomy). The open-wedge portion is usually filled in with a bone graft.

Delayed union or *nonunion* is another complication of fracture treatment. The broken ends of the bone become sclerotic and rounded off, and the fragments are united by fibrous tissue rather than by solid new bone. Frequently a pseudarthrosis forms; (that is, a fibrous envelopement encloses the ends of the bone, and a glairy fluid not unlike synovial fluid collects within the sac), resulting in an uncontrollable instability of the extremity.

There are numerous factors which produce nonunion. One is the relation of the blood supply to the fracture line. Therefore, nonunion is especially prone to occur in a fracture at the junction of the lower one third and upper two thirds of the tibia, at a comparable site in the humerus, at the neck of the femur, at the carpal scaphoid, and at the medial malleolus. In these areas the fracture line cuts across the main blood supply and deprives one of the fragments of sufficient nutrition to support the healing process.

Another cause of nonunion which applies to any site is inadequate immobilization of the affected part. If the bone ends are allowed to move against each other frequently, repair may cease, and nonunion will result.

Distraction of the fracture site can result in nonunion. It is easy to understand that if there is too much distance between the bone ends, callus may fail to bridge the gap.

The amount of bone in contact with bone sometimes produces nonunion. At least one half of one bone end should be in contact with an equal surface of the other fragment.

Interposition of the soft parts may block the callus formation and lead to nonunion. It is easy to understand that a large muscle belly or a stout ligament interposed between the fracture ends may act as an effective barrier, preventing a bridge of callus to form and unite the fracture fragments. As a matter of fact, there is some evidence that nonunion in a fracture of the medial malleolus of the ankle is due not to a loss of the blood supply, but rather to the interposition of a ligament between the fracture surfaces. In open reduction of a fracture of the ankle, a large ligamentous tab is sometimes seen situated between the fracture surfaces of the medial malleolus and the tibia. Nonunion in such a circumstance would seem the logical outcome.

Joint fluid is said to be inimical to the healing of bone, and therefore an intra-articular fracture has a tendency not to unite. It is a common observation that the blood within a joint often does not clot. Therefore, if sufficient joint fluid were present at the fracture site it is conceivable that the joint fluid could hinder the formation of the hematoma and its transformation into callus. However, we believe that undue emphasis has been placed upon the role of joint fluid in the hindering of the healing of a fracture.

Open reduction per se seems to delay union. This may be due to the removal of the hematoma which acts as a basis for the developing callus.

To summarize, some of the common situations producing nonunion of fragments are the relation of the blood supply to the fracture site, inadequate immobilization of the fragments, distraction of the fracture fragments, the amount of

After definitive treatment of the wound has been carried out, an adequate cast is usually applied. Doubts have arisen in the past concerning the wisdom of placing a sulfonamide in a compound wound, with the systemic administration of a sulfonamide or penicillin thereafter. Chemotherapy has probably been of help in the management of a compound fracture, but more important considerations in combating infection seem to be early treatment of the wound, careful surgical toilet of the wound, the extent of damage to the soft tissue, the adequacy of the blood supply, and the number and type of contaminating objects within the wound.

Complications of Fractures

Certain complications of fractures should be considered because of their relative frequency.

Malunion is the term applied to a fracture which has united in a deformity. This may be caused by any one of several reasons: (1) inadequate reduction, (2) neglect by the patient, (3) failure of the practitioner to observe the general principles of fracture treatment, especially the immobilization of the joint above and the joint below the fracture site, (4) softening of the cast, or (5) slipping of the fragments within a poorly constructed or improperly applied cast. Malunion may or may not be of importance from the standpoint of restoration of function. A relatively slight amount of malunion at an important location may be very disabling, whereas a moderately severe degree of malunion at another site may not disable the patient at all.

The roentgenograms may reveal a slight deformity, not apparent by inspection, which may not interfere with function. Not infrequently, however, the deformity is conspicuous and does interfere with function, either because of the loss of a normal angle or because of a bony block within the joint. Corrective procedures, usually a type of osteotomy, have been devised to correct malunion. In such procedures the bone is cut through, and the correct alignment is obtained. The part is then treated as *a fresh fracture. The two main types are the closed*-wedge and the open-wedge osteotomy.

If a patient has suffered a fracture of the distal radius (Colles' fracture) which was not adequately reduced and healed with a dorsal deformity of the distal fragment, the area can be exposed surgically and the bone cut through entirely or almost entirely Then the distal fragment is brought volarward into its proper alignment. This procedure leaves an open wedge-shaped space on the dorsal surface, hence giving the procedure its name. The open-wedge portion may be allowed to fill in with new bone, or it may be packed with bone chips to aid the healing.

Occasionally in a fracture through the distal femoral epiphyseal plate, the distal femoral epiphysis unites with the shaft in such a manner as to force the lower leg into a lateral position at the knee (valgus deformity) For this condition an osteotomy may be performed either medially or laterally just above the condyle. If it is performed on the medial side, a wedge-shaped piece of bone is removed, and the lower leg is swung inward to the proper position. Thus, the operative gap is closed (closed-wedge osteotomy). If the lateral surface is chosen for the procedure, the bone is cut through, and the leg is swung medially. This

ischemic contracture the muscles are eventually replaced by fibrous scar tissue, and the hand and fingers become clawed and stiff. The disability is grave. Therefore, it is wise to feel the pulse and observe the circulation in the nail beds regularly for twenty-four hours after a supracondylar fracture of the humerus. If the circulation is severely impaired, severance of the deep fascia and periarterial sympathectomy, together with open reduction, may be indicated.

Some of the common nerve palsies after a fracture or dislocation result from damage to the radial nerve, manifested by wrist drop; the peroneal nerve, revealed by foot drop; and the tibial nerve, indicated by anesthesia of the sole of the foot and weakness in plantar flexion in the foot. In a fracture of the midshaft of the humerus, a wrist drop frequently occurs. Usually it is transient and clears up within ten to fourteen days. If it is transient, it is due to compression of the radial nerve (as it passes posteriorly around the midshaft) by edema and local hematoma. If the wrist drop tends to persist, the radial nerve is probably either severed or caught between the bone ends. Exploration, repair of the nerve, and open reduction are indicated if the wrist drop persists much longer than two weeks. A fracture around the knee often produces a transient foot drop due to the pressure of edema upon the peroneal nerve as it winds around the neck of the fibula. Sciatic nerve palsy may occur in association with traumatic posterior dislocation of the hip. It may be either transient or permanent, depending upon the severity of the injury. It is obvious that the practitioner *must* have a beforehand knowledge of which nerves are likely to be injured by a particular fracture in order to determine whether the fracture has actually involved the nerve. Needless to say, it is very embarrassing to perform a procedure in the treatment of a fracture and then afterward to discover a nerve palsy. The question of whether the palsy antedated the procedure or was caused by it immediately arises. A thorough examination for a nerve palsy before treatment can prevent difficulties of this sort

Incongruity of the joint surfaces leading to post-traumatic arthritis is another complication frequently following an intra-articular fracture. Such a fracture may heal with sufficient incongruity of the joint surfaces to produce marked limitation of motion and disabling pain upon use. Furthermore, joint incongruity of even an apparently slight degree can lead to the early development of a painful hypertrophic arthritis called post-traumatic arthritis. Treatment for such a condition in a joint is by either arthroplasty or arthrodesis and will be discussed latter.

Another complication is arrested growth. A fracture of an epiphyseal plate may either arrest or stimulate growth, the result being a deformity in either instance. Due to the fact that growth takes place at the epiphyseal plate, a bad deformity is likely to result unless excellent reduction has been carried out.

In summary, some of the complications of a fracture are malunion, nonunion, infection, vascular embarrassment, nerve injury, arrested growth, and incongruity of the joint surfaces leading to post-traumatic arthritis.

Physical Therapy in the Aftertreatment of Fractures

Physical therapy is often used in the aftertreatment of fractures. After a cast has been removed, several conditions are immediately apparent. First,

...e fragments, interposition of the soft parts, the presence ... reduction per se.

... that a fracture occurring as a result of the destruction of ...astatic tumor usually heals well.

... of managing nonunion is to operatively refresh the eburnated ...union and drill multiple holes through the bone ends. Then the ...ed in a fresh fracture is carried out.

...er method is to perform a bone graft. The site of the nonunion is exp... , and the bone ends are refreshed. A graft is cut from some convenient area, such as the tibia or the iliac crest, placed to bridge the nonunion, and fixated to both fragments. This procedure is called the single onlay graft. If it is desired, two onlay grafts, one on each side of the fracture, may be used (double onlay graft). The latter is probably the most efficient method because it provides good immobilization at the grafted site, and if one graft fails to take, the other may be successful.

Other methods of managing nonunion are the insertion of a bone graft directly into the medullary cavity (intramedullary peg) and use of the so-called sliding graft. In this latter procedure, a graft is cut directly across the site of the nonunion. Then it is lifted out of its bed, reversed, and replaced so that it bridges the site of the nonunion.

The cells in a bone graft undergo necrosis and leave a scaffolding upon which the new bone is laid down, due to the invasion of the area by new blood vessels and osteoblasts. The graft is thereby reconstructed and incorporated into the host bone.

Another complication in the treatment of a fracture is the possibility of *infection* in a compound fracture or in the wound of an open reduction. Open reduction converts a simple fracture into a compound one, at least theoretically. The treatment for an acute wound infection which involves the bone or joint is along the general surgical principles of drainage, irrigation, and systemic administration of antibiotics.

Vascular embarrassment or *nerve damage* may be another complication of fractures. The sharp end of a fractured bone may easily sever either a blood vessel or a nerve. Therefore, it is wise to perform a neurologic examination of the involved part, testing both the sensitivity of the skin and the motor power of the muscles likely to be affected by the nerves in the vicinity of a given fracture. It is true that testing the motor power may be difficult in the presence of the pain produced by attempts at motion. Failure to perform a motion because of nerve injury cannot always be distinguished from the failure due to great pain.

A fracture, especially a compound one, may result from such severe violence that, as an associated injury, the blood vessels may be lacerated, or the ends of the fracture may be pressing upon a main vascular trunk. Therefore, the status of the circulation in the region distal to the fracture should be noted. The status of the circulation must be noted in a fracture or dislocation around the elbow joint, for example, a supracondylar fracture of the humerus or a posterior dislocation of the elbow. Volkmann's ischemic contracture may result from a circulatory embarrassment following either of these injuries. In Volkmann's

ischemic contracture the muscles are eventually replaced by fibrous scar tissue, and the hand and fingers become clawed and stiff. The disability is grave. Therefore, it is wise to feel the pulse and observe the circulation in the nail beds regularly for twenty-four hours after a supracondylar fracture of the humerus. If the circulation is severely impaired, severance of the deep fascia and periarterial sympathectomy, together with open reduction, may be indicated.

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Physical Therapy in the Aftertreatment of Fractures

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the muscles of the affected area are wasted and atrophic. They have a nonresilient consistency to palpation. They are weaker than normal and are inelastic and stiff when moved, either passively or actively. Second, the joints of the affected area have a markedly diminished range of motion; that is, they are stiff. Furtheremore, passive or active motion of the joint is painful. Third, the area may be tender to palpation. The objectives of physical therapy, then, are to develop a normal range of motion in the joint and to alleviate the pain.

In general the application of heat to the affected area relaxes the muscles and alleviates the pain. Currently there are numerous ways in which heat is applied. One method is the use of the infrared heating lamp which may be used in conjunction with a hot pack, that is, a woolen cloth soaked in hot water and applied to the affected part. Another method is the use of the whirlpool bath. The whirlpool bath is an oval tank filled with water heated to a temperature of approximately 115° F. A stream of air is forced through the water, causing it to swirl around. The advantages of this apparatus are that the heat relaxes the muscles and stimulates the circulation, and the gentle action of the moving water performs a passive motion on the immersed extremity. Short wave diathermy is also used as a method of applying heat. Short wave diathermy is essentially the passing of an electric current of radiofrequency into the body. The deep tissues act as the resistance to the electric current and thus heat is developed deep within the body. Since metal within the body, especially, becomes heated by diathermy, diathermy should not be used at a site where metal internal fixation materials, such as screws, plates, Vitallium cups, etc., are present for fear of burning the deep tissues.

Following the application of heat the physical therapist massages the extremity to reduce edema or to stimulate local circulation.

Attention is next directed to the development of motion in the joint. The type of motion will depend upon the particular stage of the treatment. When the cast is first removed, passive motion is used. The physical therapist moves the joint through as large a range of motion as possible without exertion, without pain, and without aid from the muscles. After several days, or whenever it seems indicated, active assistive motion is begun. The patient, with the help of the physical therapist, moves the joint through as large a range of motion as possible. As the musculature develops sufficiently, active motion is introduced. The patient moves the joint himself without help from the therapist. The next step is to develop the muscles to their fullest capacity, using active resistive exercises. The patient moves the part in one direction, and the physical therapist offers resistance to the movement. Weights to furnish the resistance may be substituted for the therapist. If the range of motion is not developing satisfactorily, stretching exercises are started. The physical therapist moves the affected joint as far as possible without producing pain and stretches the part little by little to obtain a greater range. Undue pain to the patient should be avoided, however.

Relaxed motion, used in certain special instances, is very gentle and depends upon gravity. For example, it may be used in the treatment of certain shoulder injuries. The patient stands and bends forward at the hips, allowing the upper

extremity to dangle. He then moves his body in such a manner as to cause the upper extremity to swing in an arc, much like a pendulum. Thus, the motion at the shoulder is neither passive nor active, but relaxed.

In summary, the objective of physical therapy is to re-establish as much as possible of the normal function of the affected extremity by the use of heat, massage, and various types of joint motion and exercise.

EMERGENCY MANAGEMENT OF CERTAIN TRAUMATIC CONDITIONS

When the doctor is called to the scene of an accident, he must make a rapid diagnosis without the benefit of the facilities available in a hospital. Many times the advice and orders he gives and the judgment he exercises in these undesirable circumstances can profoundly influence the end recovery of the patient. The following suggestions may be of help to the physician in giving emergency instructions.

If a person injured in an automobile accident is found lying on the ground and complaining of back pain, the doctor should suspect a compression fracture of the vertebral column or even a fracture dislocation. It should be realized that flexion of the back may cause spinal cord injury if a compression fracture or dislocation does exist. Therefore, if the patient is not given proper management and transportation, he may develop a paraplegic condition. Instead of a compression fracture, there might be a fracture of the posterior bony arch of the vertebra. If this is true, extension of the back may cause paraplegia. Therefore, both flexion and extension of the back are potentially dangerous. In transporting the patient to a hospital, *his back should be placed on a rigid support.* He should *not* be moved until a rigid support is available. After he has been admitted to a hospital, x-ray pictures will confirm or deny the suspected lesion. It is better to observe this safeguard, even at the expense of appearing ridiculously cautious, than to be guilty of causing paraplegia in a patient.

If, at the scene of an automobile accident, the victim complains of neck pain, the doctor should assume that a potentially very dangerous lesion is present. The patient may simply have strained the neck ligaments and muscles but, even so, should be managed as if he had a dislocation of the cervical spine and might develop a paraplegic or quadriplegic condition at any moment. If the patient holds his head tilted or if he states that he felt a transient or momentary sensation like an electric shock anywhere in his body, the physician must be especially on the alert to the possibility of injury to the cervical spine. Such a patient should be transported to a hospital with his head and neck held immobile by a trusted, skilled, and competent attendant or by the doctor himself. X-ray pictures should be taken forthwith to determine whether or not a serious injury exists.

If the complaint involves an extremity, a tentative diagnosis at the scene of an accident is easier to reach, and it does not carry so grave a potential danger as does injury to the vertebral column. Obvious deformity can be diagnosed, of course, as a probable fracture Splinting of the extremity in one manner or other before transportation should be done to prevent compounding, to decrease

pain, to aid in preventing shock, and to prevent the fractured bone ends from lacerating the blood vessels, nerves, or tendons. There are numerous ways to immobilize an extremity. A padded, long aluminum splint can be used on the lower extremity in a fracture involving the knee and the parts distal to it, provided the splint extends high enough up the extremity. If such a splint is not available, padded wooden splints can be applied to both sides of the injured part. Lacking such equipment, the physician can bind the injured lower extremity to the opposite extremity, provided it also is not suspected of a fracture.

If the injury is to the femur or if a fracture or dislocation of the hip is suspected, a Thomas splint can be applied, with a traction hitch at the ankle. The traction should not be too great. Special care should be used if a traction hitch is applied at the ankle. If adequate padding is not available to assure normal circulation in the foot when the traction hitch is applied, the Thomas splint should not be used at all. In the upper extremity splints may be used for a suspected fracture of the forearm and wrist. In injuries to the shoulder, humerus, or elbow, the arm may be immobilized against the body by applying bandages around the chest.

If the injury is a compound fracture, the physician should remove all gross objects, such as bits of clothing, leaves, twigs, etc., from the wound. The wound should then be thoroughly covered with sterile gauze and bandaged. Dangerous bleeding from a compound fracture is not especially common, but any bleeding should be controlled immediately. A sterile pressure dressing is the best method to use. A tourniquet should be avoided if at all possible. It may very well stop arterial bleeding, but venous bleeding may continue and result in a serious blood loss. A tourniquet also has the disadvantage of requiring frequent release, a detail which, if overlooked, has a catastrophic result. Following the dressing of the compound wound, splinting is carried out as just described for a simple fracture. After the patient has been admitted to a hospital, definitive treatment is carried out along the lines previously discussed.

In many instances an injured person is brought to the physician's office. This is usually the case in the presence of lacerations. Lacerations and their treatment constitute a peculiarly treacherous problem. An apparently relatively small cut may hide a lacerated tendon or nerve or a compound wound of a joint. An apparent clean and somewhat insignificant cut may develop into a dangerous tetanus infection or a fulminating infection of either a tendon sheath or a joint. It may also result in a peripheral motor or sensory deficit if the nerve severance is overlooked. Therefore, the doctor is urged to examine the area carefully, keeping in mind the possibility of a hidden laceration of tendons and nerves and wound of a joint.

It is well to remember that a tendon may be only partially lacerated and therefore can function in a seemingly normal fashion at first, only to rupture at a later date. It is wise to assume that if a laceration is so located that it could injure a tendon, nerve, or joint, the injury has, in fact, occurred. The patient should be requested to move the affected part to test for motor power, which might be lacking because of a nerve laceration, and to determine whether there is partial or complete tendon laceration. Sensory examination distal to the skin

laceration is indicated. If especially experienced medical help is readily available and if laceration of the nerve or tendon is suspected, the wound should be cleansed, the bleeding stopped (perferably by pressure dressings), and the condition referred without delay to those with specialized knowledge. It is particularly wise *not* to probe and explore such lacerations.

If special advice is not readily available and if laceration of the nerve or tendon is suspected, the wound should be cleansed, débrided, irrigated, and closed, without suturing the tendon or nerve. Tetanus antitoxin (or toxoid) and antibiotics should be administered after the usual precautions for possible sensitivity in the patient have been taken. The affected part should be immobilized. The patient may then be referred, in a more leisurely manner, to a specialist for definitive treatment of the nerve or tendon which was left unsutured.

REHABILITATION

Rehabilitation is the primary achievement that every physican desires for his patient; this is what he means by the word "cure." No matter what the patient's complaint might be, the doctor thinks in terms of the control of pain, the amelioration of symptoms, the restoration of function, and the ultimate return of the patient to the community as a productive citizen. In the broad sense, rehabilitation is the restoration of the patient to self-sufficiency or to gainful employment at his highest obtainable skill in the shortest possible time. Rehabilitation, then, is not a technique, but a series of techniques united in what can be called a philosophy of total medical care. Unfortunately, in the years following World War II the total concept of rehabilitation was somewhat clouded because every group interested in this field appeared to have a different concept. To many people, particularly the lay public, rehabilitation has become synonymous with physical medicine, while to others it means vocational training. So it goes on down to specific rehabilitation, such as for the paraplegic patient. For this reason it is necessary to have a clear picture of what actually constitutes rehabilitation and to know precisely where in this broad field the physician's real responsibility falls.

A review of the factors comprising a successful rehabilitation program may give us a clear, broad concept.

Factor 1. The rehabilitation goal for each patient depends upon the extent and severity of the disease or injury.

Factor 2. Rehabilitation depends upon the competence with which the acute emergency was managed, be it medical or surgical. The obvious examples are the need for proper treatment of a compound fracture and for the proper repair of a tendon laceration In each case an inadequate immediate repair can never be overcome, despite all later aftercare efforts.

Factor 3: Rehabilitation depends on adequate treatment during the convalescent period. In the case of poliomyelitis, it is necessary that the physician in charge understand the possible complications of the disease and begin their prevention early. He must institute stretching exercises to prevent contracture, provide proper splinting of the affected part, suggest proper timing in the use of braces, etc. Exercises should include those taught through work therapy.

The patient must be given specific instructions as to how, why, and when the exercises should be done. *This means that the physician must give scrupulous* attention to every detail. Unfortunately many physicians feel they have no time for such detailed supervision, yet it is just as important an aspect of adequate care as the treatment of the acute emergency and is therefore a task which we must not shirk. If rehabilitative facilities are not immediately available, they should be sought out and placed at the patient's disposal.

Factor 4: Rehabilitation demands that those working in the field recognize that disease and trauma can produce psychologic complications which often are brought on by a feeling of insecurity when the patient realizes he may have a loss of income and, possibly, a permanent disability of some sort.

Factor 5: Rehabilitation calls for the continued efforts of the physician on behalf of those patients who have a permanent disability. It is in the area of the permanently handicapped person that a doctor must acquaint himself with the further possibilities of training, vocational guidance, and ultimate employment so that he can direct his patient to the proper specialists, thus providing a continuity of treatment. All too often the physician feels that the task is complete when he has gone as far as possible in the correction of the underlying medical disability. There is no doubt that from this point onward the patient is a community problem. Nonetheless, it is essential that the doctor continue to direct, advise, and encourage the patient in his efforts at further training and ultimate employment. In this circumstance the physician must seek the help of vocational counsellors, vocational training facilities, employment agencies for handicapped persons, sheltered workshops, and any other agencies whose purpose is to reclaim disabled persons When this cycle has been completed, then and then only can one say that a patient has been rehabilitated.

Rehabilitation Centers

Most family doctors are geographically remote from existing rehabilitation centers. In spite of this the public is well enough informed on matters of rehabilitation that they are in many instances demanding this type of care. Many times the patient who demands so-called rehabilitation is not aware of all of the facts, and it is therefore the family doctor's duty to direct his thinking in these matters. It must be recognized that the existing centers in most instances have been set up to train persons with specific disabilities and do not offer complete and total rehabilitation. An example is the rehabilitation center established by an insurance company to which an injured worker is sent to receive specific exercises and training which will enable him to overcome a handicap and prepare him for re-employment in a different job at his same place of employment. This is an extremely necessary type of rehabilitation but does not serve the needs, for example, of a severe arthritic patient who has not previously been employed but who might become employed if he receives the proper surgical restoration and muscle re-education and reaches his maximum physical fitness. To do all of these things for the patient with a severe arthritic handicap requires more than a specialized rehabilitation center offers. It requires a particular type of center in

which all the facilities for surgical correction, physical restoration, vocational training, and job placement are available. Such centers are being developed, and it is hoped that in the foreseeable future there will be many such facilities. It behooves each doctor to find out how many of these facilities are available in his own community so that he can direct his patients to the proper agencies.

Most states now have agencies equipped to test the aptitude, provide specific training, and provide job placement services for the disabled person, and the Federal Government is giving an ever-increasing amount of financial aid to carry out these activities. It is important for the family doctor to be aware of these facilities, which are becoming increasingly available, that will enable him to direct a rehabilitation program integrated to the needs of a patient. A single telephone call to the nearest vocational rehabilitation division will initiate a training program for his patient.

Physical Restoration

Since the family doctor is likely to be the one treating a patient for disease or injury, he must be aware of the importance of returning each patient to maximum physical capacity in the shortest time. In the great majority of patients he is able to direct the medical care, which is the first phase of rehabilitation, and has at his command the entire medical profession for consultation, when and if he desires it. This will usually see him through the acute phase. It is in the convalescent phase that he is likely to need the help of others, such as the physical therapist and the occupational therapist. Because of the lack of training in the fields of physical and occupational therapy (and at times a lack of interest), many physicians do not know the various modalities of treatment in the two fields. For this reason, it may be of help to the practitioner to know the commoner forms of therapy in use and, more important, how to order a specific therapy so that the cooperation of the physical and occupational therapists is assured. We have included, therefore, a few simple line drawings to illustrate the various modalities of treatment which can be called for on the order blank when referring a patient to the physical or occupational therapist.

Physical Therapy.—Physical therapy is the treatment of a disease by various nonmedical and nonsurgical means. It comprises the use of heat, light, water, electricity, massage, exercise, and other supportive measures. Physical therapy may be given to one extremity or part of the body, to several extremities, or to the entire body, depending upon the diagnosis of the disease and the condition of the patient. The major objectives are to increase the range of motion of the joints, to strengthen the muscle power, to provide gait training of various types, to relieve pain, and to bolster the patient's morale and spirit. The therapist who carries out the treatment needs direction from the physician in charge. This is best accomplished by direct discussion of the problem by telephone or, better still, in person. If discussion is not possible, it is mandatory that the therapist have some direction in writing, and the physician in charge should order specific modalities of treatment rather than just write on a prescription blank "physical therapy." A simple prescription will furnish adequate information so that the therapist may proceed with the treatment. The prescription

blank which follows illustrates the pertinent information to be included in the directions to the therapist. Figs. 65 to 87 illustrate the special treatments which can be requested on the referral blank.

(Text continued on page 161.)

REFERRAL BLANK

Name________________________________

Age__________ **Diagnosis**____________________

____

Objective of Treatment____________________

____

Special Treatment________________________

____

Precautions____________________________

Signature___________________________

Date______________________________

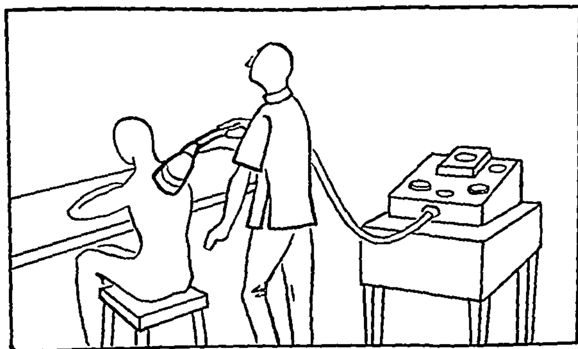


Fig 65.—Ultrasonics Name area to receive treatment.

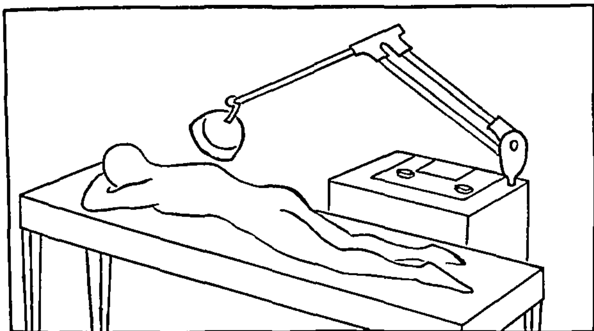


Fig 66 —Diathermy. Name part to receive treatment.

Fig. 67.—Whirlpool bath. Give diagnosis for treatment.

blank which follows illustrates the pertinent information to be included in the directions to the therapist. Figs. 65 to 87 illustrate the special treatments which can be requested on the referral blank.

(*Text continued on page 161.*)

REFERRAL BLANK

Name________________________________

Age__________ **Diagnosis**______________________

____

Objective of Treatment______________________

____

Special Treatment__________________________

____

Precautions______________________________

Signature____________________________

Date_______________________________

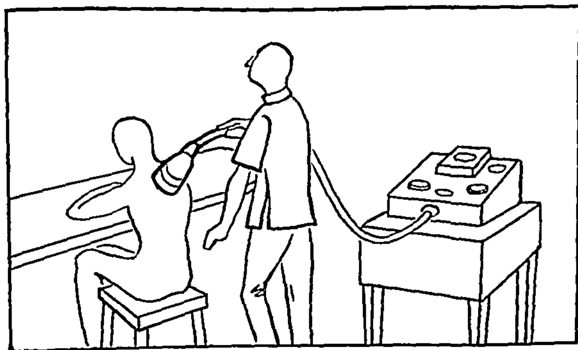


Fig. 65.—Ultrasonics. Name area to receive treatment.

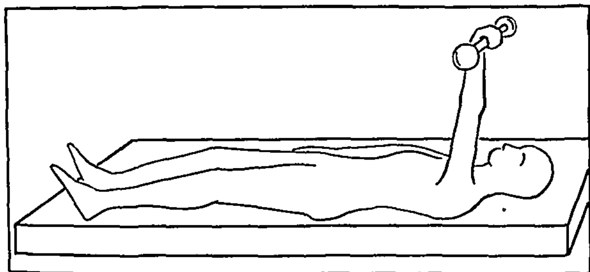


Fig. 70.—Active exercise. Name muscle groups.

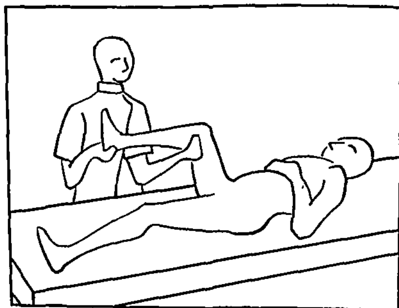


Fig. 71.—Assistive exercise. Name muscle groups.

Fig 68.—Electrical stimulation. Name specific muscles.

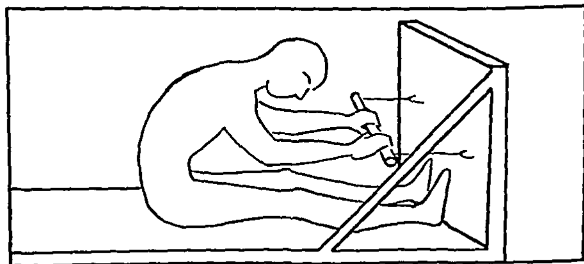


Fig. 69.—Active stretching. Name muscle group.

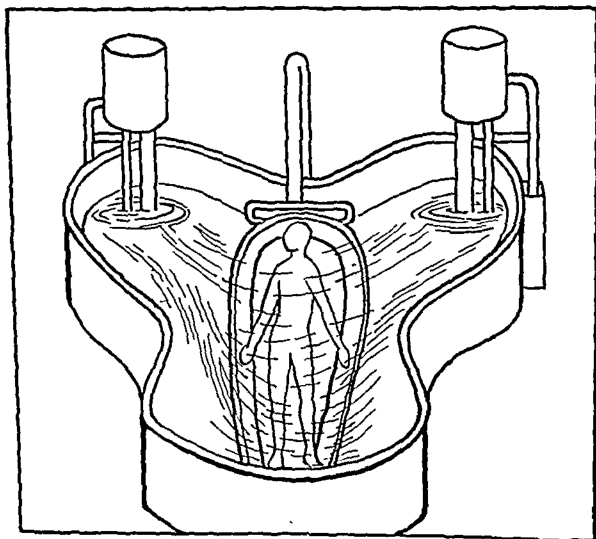


Fig. 74.—Hubbard tank Name condition to receive treatment.

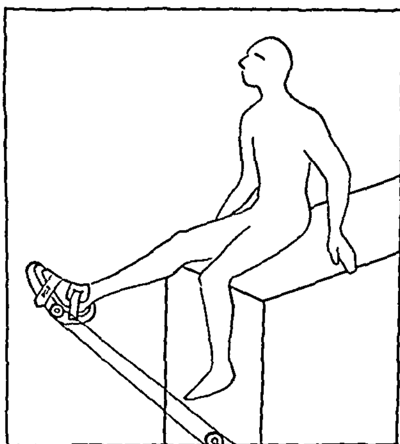


Fig 72.—Resistive exercise. Name muscle groups.

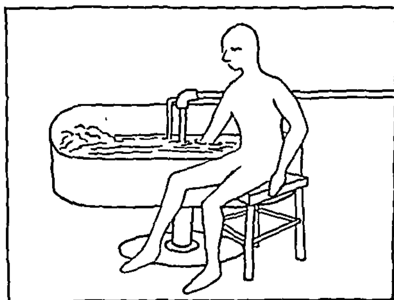


Fig. 73.—Arm bath. Name condition to receive treatment.

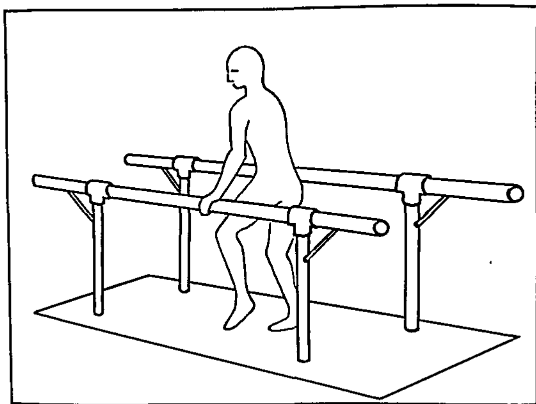


Fig. 77.—Gait training. Parallel bars.

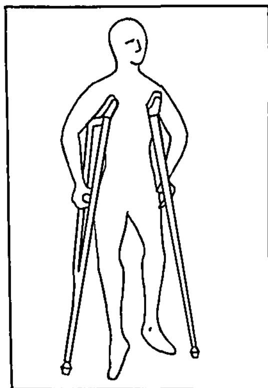


Fig. 78 —Gait training Weight-bearing and nonweight-bearing.

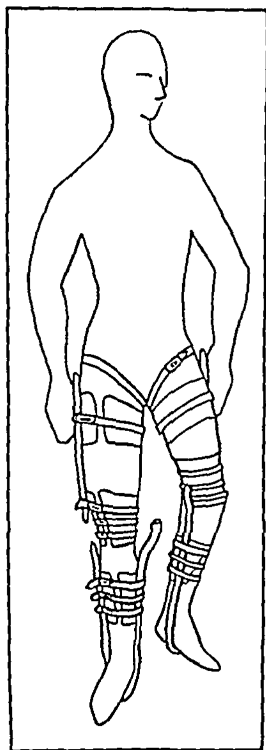


Fig. 75.—Bracing Name part to be braced.

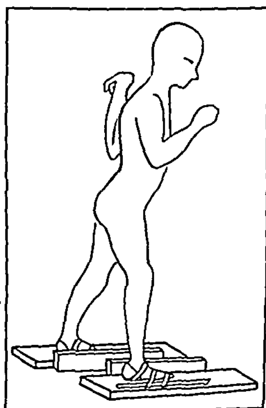


Fig. 76.—Cerebral palsy. Walking with skis for balance training.

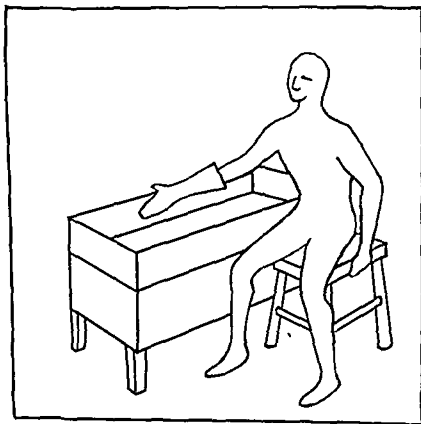


Fig. 81.—Paraffin bath.

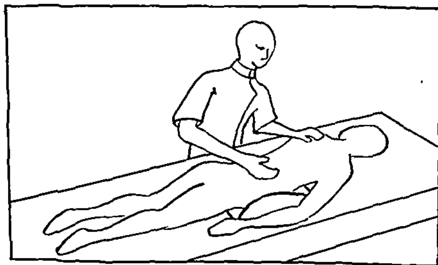


Fig 82.—Massage. Name area to receive treatment.

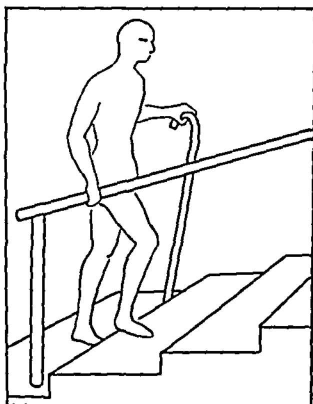


Fig. 79 —Stair climbing

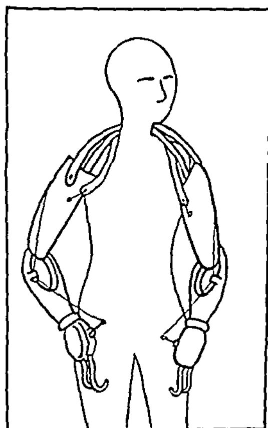


Fig 80 —Prosthesis.

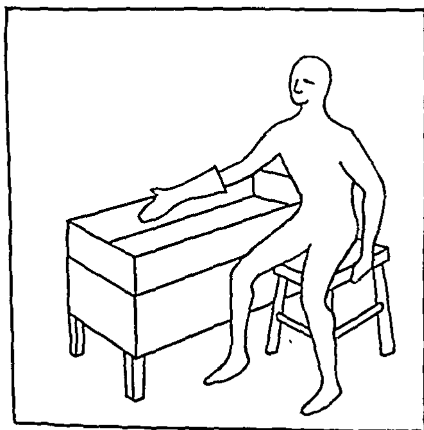


Fig. 81.—Paraffin bath.

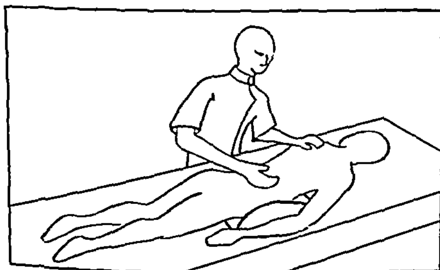


Fig. 82.—Massage. Name area to receive treatment.

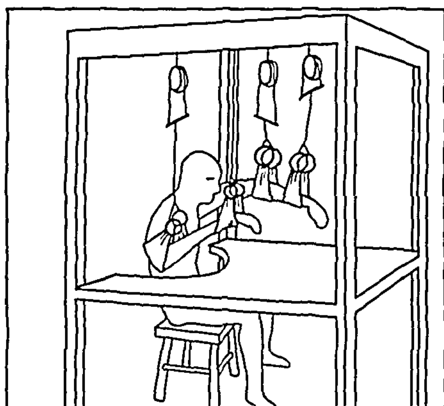


Fig. 83.—Suspension slings.

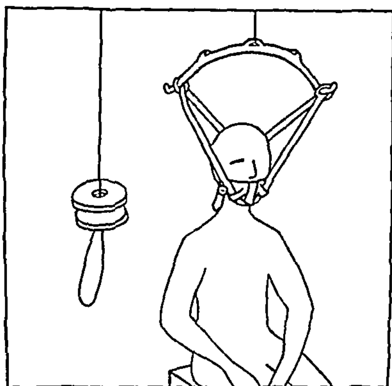


Fig. 84.—Neck traction. Give diagnosis, length of treatment, and amount of traction.

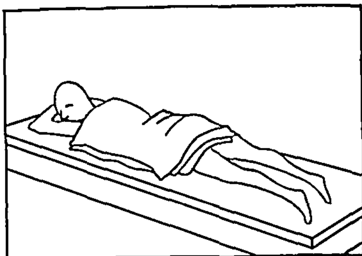


Fig. 85.—Hot packs. Name part to receive treatment.

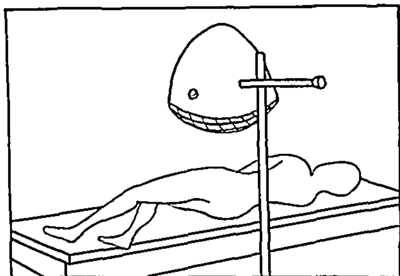


Fig. 86 —Infrared treatment. Name part to receive treatment.

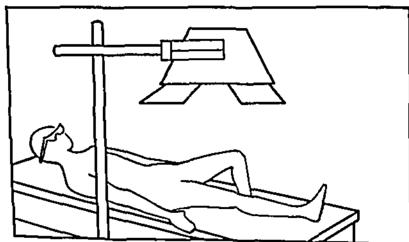
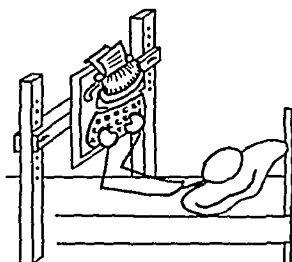
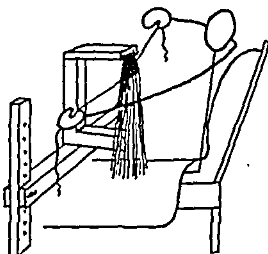


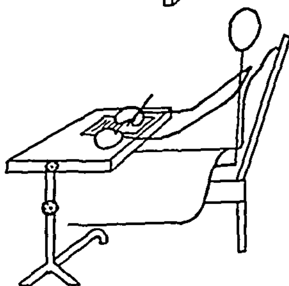
Fig. 87.—Ultraviolet treatment. Name area to receive exposure.



Typing



Cord Knotting



Writing

Fig 88 —Activities in bed

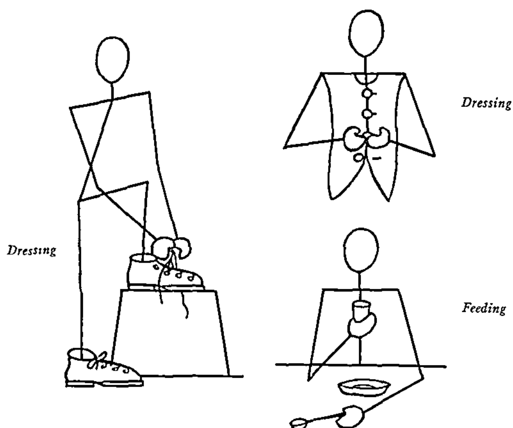


Fig. 89.—Activities of daily living.

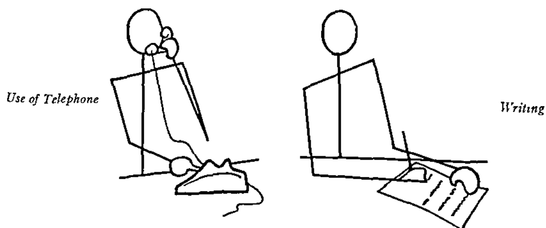
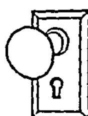
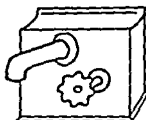


Fig 90 —Activities of daily living.





Use of Household Objects





Fig. 91.—Activities of daily living.

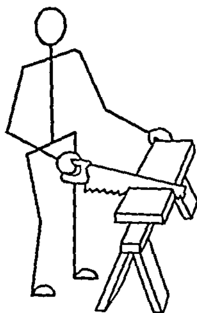


Fig. 92.—Woodworking—sawing.

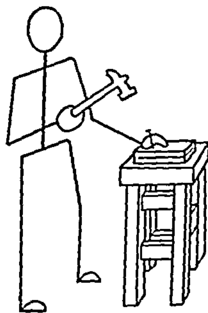


Fig. 93.—Woodworking—hammering.

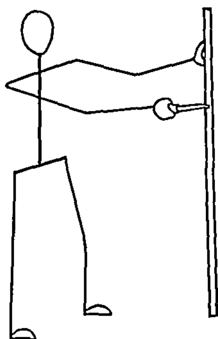


Fig. 94.—Woodworking—use of screw driver.

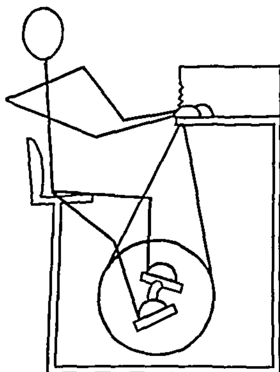


Fig. 95.—Woodworking—bicycle jig saw.

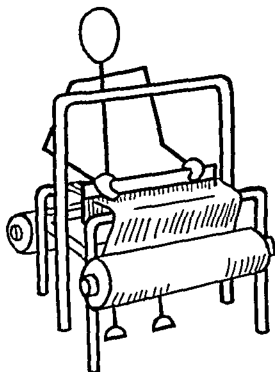


Fig. 96.—Weaving on floor loom.

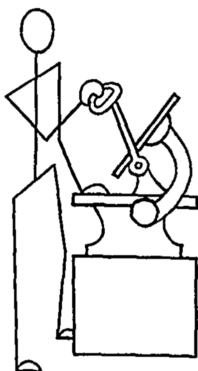


Fig. 97.—Printing on hand press.

Occupational Therapy.—The major objectives of occupational therapy are to increase joint motion and muscle strength, to improve coordination, to improve and maintain morale, and to train weakened muscles in compensatory motions by means of a program of graded activity. The three broad classifications of these activities are (1) instruction in the skills needed to meet "demands of daily living," (2) instruction in the manual skills such as crafts and typing, and



Fig. 98.—Working with clay.

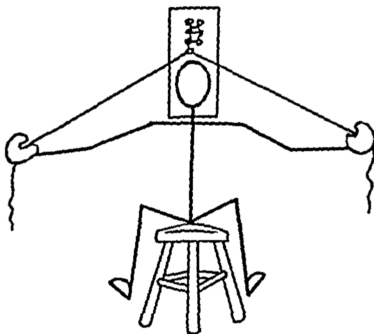


Fig 99 —Cord knotting.

(3) instruction in recreational skills. In order that the occupational therapist may initiate a medically safe and therapeutically beneficial program, a written prescription by the attending physician is required. The same prescription blank used to request physical therapy may be used to request occupational therapy. A general sampling of the types of activity employed by the occupational therapist is given in Figs. 88 to 99

Chapter Three

Disturbances of the Foot and Ankle in the Adult*

ANATOMY

It will be assumed that the reader is familiar with the anatomy of the foot, and only certain facts of importance will be stressed here. The body of the talus fits snugly in the mortise formed by the medial malleolus of the tibia, the distal end of the tibia, and the lateral malleolus of the fibula. Motion of the talus within this articulation allows dorsiflexion and plantar flexion of the foot. The head and neck of the talus extend downward, forward, and medially. The head articulates with the scaphoid bone. Inferior to the body of the talus and supporting it is the calcaneus The calcaneus forms the prominence of the heel, then extends forward and laterally below the talus, and articulates with the cuboid on the lateral border of the foot. Between the talus (or astragalus) and the calcaneus is an articulation called the subastragalar joint. It is at this point that inversion and eversion of the foot take place. As has been inferred, the scaphoid lies on the medial border of the foot and articulates in back with the head of the talus and in front with the three cuneiform bones. The cuboid lies on the lateral border of the foot and articulates in back with the calcaneus and in front with the fourth and fifth metatarsals. The cuneiform bones are wedge-shaped and three in number and are arranged to form a transverse arch, with a concavity toward the plantar aspect. The first three metatarsals articulate with the cuneiforms.

Briefly, the main muscles can be grouped into those of dorsiflexion, those of plantar flexion, and those of inversion and eversion. The extensor hallucis longus and the extensor digitorum longus, together with the tibialis anticus and the peroneus teritus, are responsible for dorsiflexion. Plantar flexion is performed by the gastrocnemius, the soleus, the flexor hallucis longus, and the flexor digitorum longus muscles. After a certain degree of equinus is reached, the peroneus longus and the peroneus brevis also aid in plantar flexion. Eversion is carried out by the peronei (longus, brevis, and tertius), together with

*See also Disturbances of the Foot and Ankle in Infancy and Childhood (page 33) in Chapter 1, Diseases or Affections in Childhood.

the lateral portion of the extensor digitorum longus. Inversion is accomplished by the tibialis anterior and tibialis posterior muscles.

The plantar fascia attaches to the calcaneus and to the distal portion of the metatarsals. There are two main arches in the foot, the longitudinal and the transverse.

Orthopedic examination of the foot is discussed under specific affections.

TRAUMATIC INJURIES TO THE LOWER LEG, THE FOOT, AND THE ANKLE

Complaint	Likely Diagnoses	Page
Acute injury, pain in lower leg or ankle, inability to bear weight, possible deformity of leg	(1) Fracture of tibia and/or fibula	166
	(2) Fractures of ankle	168
Previous injury, pain and swelling of ankle, ability to bear weight maintained	(1) Post-traumatic arthritis of ankle	172
	(2) Diastasis of ankle	173
Acute injury, pain and swelling of foot or ankle, difficulty in bearing weight	(1) Fractures of tarsus	173
	(2) Fractures of metatarsals	176
	(3) Fractures of phalanges of toes	176
	(4) Sprained ankle	177
	(5) Avulsion fracture of neck of talus	178
Sudden, painful deformity of foot during convalescence from previous injury, difficulty in bearing weight	(1) Post-traumatic spastic valgus deformity of foot and ankle	179

Fractures of the Tibia and/or Fibula

In a fracture of the lower leg the treatment depends upon whether or not one bone is intact. If the fibula is intact, it acts as a splint, and, therefore, a fracture of the tibia alone tends to remain in good position. Consequently, a cast applied from above the knee downward to include the foot is all that is usually required in a simple transverse, oblique, spiral, or comminuted fracture of the tibial shaft (if the fibula is intact). Healing requires from seven to ten weeks, depending on the age of the patient.

If the fibula is fractured in addition to the tibia, then there is no stability, and the treatment should be similar to that for a fracture of a single long bone, such as the femur or the humerus. A transverse fracture that seems to be fairly stable could be treated by the application of a cast alone. If the fracture is oblique, spiral, or transverse, with doubtful stability, then an accepted method of treatment is traction, followed in four or five weeks by a cast. Such a fracture is also treated by the use of transfixing pins with external fixation, with or without open reduction. In this method Kirschner wires are drilled transversely through

and through the leg, both below and above the fracture site. The fracture is reduced, and a cast which incorporates the wires to stabilize the fracture is applied. Open reduction with internal fixation (Fig. 100) is performed if satisfactory alignment is not obtained by other methods or if the fracture is compound.

The lower tibial shaft has a high incidence of nonunion in any method of treatment. This fact, which should be kept in mind, should encourage the practitioner to achieve an especially good reduction with close approximation of the ends of the bone. Nonunion may be treated conservatively at first and later by radical means if necessary. The conservative treatment consists of applying a walking cast and allowing the patient to bear weight on the affected extremity. The healing process is thereby stimulated. The walking cast extends

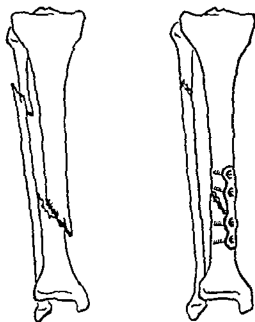


Fig. 100.—Oblique fracture of the tibia and fibula with open reduction and internal fixation.

from just below the knee to over the foot and has an especially thick sole to permit walking without damage to the cast. A walking iron, with upright metal side arms attached to a hard rubber bottom, is incorporated into the cast. This offers sufficient strength to allow weight-bearing and to prevent the cast from breaking. A rubber heel attached to the sole of the cast will serve the same purpose as either a walking iron or an especially thick sole of plaster.

If, after an adequate trial with the walking cast (two to three months), there is still no union, radical procedures are undertaken. The fracture site is exposed operatively, and the bone ends are refreshed. One of the following methods of bone grafting is then used: (1) a sliding bone graft; (2) a single or a double onlay bone graft taken from the opposite tibia; if a double onlay is performed, a full-thickness graft is cut from the opposite tibia and affixed to

the affected tibia so that it bridges the nonunion; or (3) an inlay graft; in this procedure a slot is cut in the affected bone running across the site of the nonunion, and a full-thickness graft is obtained from the other tibia and fitted into the prepared mortise. Regardless of which of the methods is used, a cast is applied and allowed to remain on until healing has taken place.

In certain special instances of nonunion, a transference of the fibula is feasible. In this operation the neck of the fibula is osteotomized, transferred to the proximal tibia, and fitted into a mortise made at this site. After healing has taken place, a second operation is done in which the distal portion of the fibula is similarly osteotomized and transferred to the distal tibia. The fibula then often hypertrophies and attemps to take over the function of the tibia. Examples of the special circumstances under which the fibula is transferred are nonunion with loss of bone substance, nonunion with chronic infection and drainage, and failure of other methods of bone grafting.

In filling out an insurance form the practitioner should estimate the total disability at eighteen to twenty weeks and the partial disability at six to eight additional weeks. Under "Anticipated Loss" he may note that nonunion is common.

Fractures of the Ankle

Fractures of the ankle are of several types. They are often sustained as a result of violent everting or inverting forces. It is probably true that violent everting forces are more likely to result in fractures than are inverting forces

Fracture of a Single Malleolus.—In a fracture of a single malleolus, the lateral malleolus (distal fibula) may reveal a transverse fracture line at about the region of the distal tibiofibular joint. (Fig. 101.) A violent everting trauma supposedly can force the talus laterally against the lateral malleolus, and thus a fracture ensues. Usually there is no significant displacement when only one malleolus is involved. The application of a plaster cast, without manipulation, is ordinarily adequate The cast remains on for about six weeks. Occasionally an isolated fracture of the medial malleolus occurs (Fig. 102), and is situated at the junction of the malleolus with the tibia. Commonly, in an isolated fracture no displacement is present, and the application of a cast for about six weeks is all that is required in treatment.

Bimalleolar Fracture (Pott's Fracture).—The bimalleolar fracture, as its name suggests, consists of a transverse fracture of the medial malleolus of the tibia at about the level of the tibial mortise and a transverse fracture of the distal fibula just above, or at, its articulation with the distal tibia (Fig. 103.) Commonly, this fracture is a result of a violent *eversion* of the foot at the ankle. During the eversion the body of the astragalus impinges upon the distal fibula (lateral malleolus), and, therefore, the latter is fractured at the site where it is bound by ligaments to the tibia The malleolus is displaced laterally. As the eversion force is continued, the ligaments anterior to the ankle joint and the deltoid ligament pull upon the medial malleolus The latter is avulsed from the tibia and displaced laterally and downward Thus, one component of the bimal-

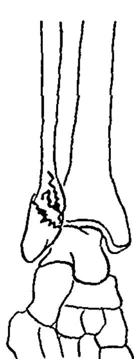


Fig. 101.—Fracture of the distal fibula.

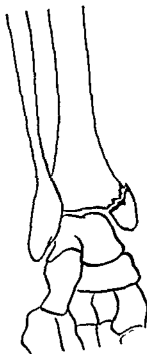


Fig. 102.—Fracture of the medial malleolus

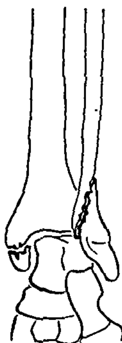


Fig. 103.—Bimalleolar fracture of the ankle.

leolar fracture is avulsion. There is edema and ecchymosis around the ankle, and a valgus deformity may be observed if the degree of displacement is marked. Point tenderness is present over both the lateral and the medial malleoli. Following the general principle of reversing the force which caused the deformity,

reduction is accomplished by swinging the foot into inversion and molding the malleoli together. The body of the astragalus impinges on the medial malleolus and presses it medially and upward into position. The ligaments, therefore, pull the lateral malleolus downward and medially from the position of valgus to a normal position. Immobilization is carried out by applying a cast from above the knee downward to include the foot. It is important to hold the foot at 90 degrees to the tibia, or foot-drop deformity may result. The foot may be immobilized in inversion. This position presses the medial malleolus back onto the tibia and tends to prevent nonunion of the malleolar fragment. In some of the milder fractures, the cast extends to, but not above, the knee. In some cases a neutral position instead of inversion is used.

The possibility of a complication in nonunion of the medial malleolus is to be kept in mind, since the fracture cuts off the blood supply to this fragment. However, it is well to remember that nonunion may not be due to a loss of the blood supply. As has been pointed out previously, a fragment of a ligament sometimes becomes interposed between the fracture surfaces, preventing the bridge of callus from forming. If close approximation of the medial malleolus has not been attained by manipulation, open reduction is recommended. In open reduction, a screw may be inserted through the malleolus into the tibia. Nonunion may produce a weak, painful ankle. If it does occur, conservative treatment is tried, using a walking cast, if this fails, radical treatment is carried out by means of multiple drillings or excision. The danger of nonunion emphasizes the need for maintaining the foot in a position of inversion and for obtaining close approximation of the medial malleolus and the tibia during reduction.

Trimalleolar Fracture (Cotton's Fracture).—The trimalleolar fracture (Cotton's) involves both the medial and the lateral malleoli as described under Bimalleolar Fracture, and, in addition, there is a vertical fracture (frontal plane) of the posterior portion of the tibia (posterior malleolus) involving the articular surface (Fig 104.) The fracture arises in the same way as Pott's fracture, except that the astragalus is also pushed backward and upward deep into the ankle joint. The patient's body as a whole continues in forward locomotion when the foot and ankle are suddenly stopped and everted. (A further extension of this force would also dislocate the astragalus posteriorly to produce a trimalleolar fracture-dislocation of the ankle—see opposite page)

The reduction for a trimalleolar fracture is accomplished by gently moving the foot between plantar flexion and dorsiflexion a few times, exerting traction upon it, bringing the foot into a 90-degree angle with the leg, inverting the foot, molding the malleoli together, and pressing forward on the posterior tibia on either side of the Achilles tendon This last maneuver is done to push the posterior malleolus into place Immobilization is accomplished by the application of a high thigh cast with the foot in inversion, the same procedure used for a bimalleolar fracture.

It is noteworthy that if more than one third of the articular surface of the tibia has been involved in the posterior and upward displacement of the posterior malleolus, then open reduction is usually the treatment of choice. The reason

for this is obvious. If more than one third of the joint surface is involved in the fracture, later joint incongruity is a likely sequel. Open reduction offers the best chance of obtaining a good joint surface. At operation both the posterior and the medial malleoli are exposed. Both are then reduced and held by screws. Moreover, as in a bimalleolar fracture, if the medial malleolus has not been satisfactorily apposed to the tibia by closed manipulation (even assuming there is a satisfactory position of the posterior malleolus), open reduction is still performed to obtain good position of the medial malleolus.

In filling out an insurance form the practitioner should estimate the total disability at twelve to fourteen weeks and the partial disability at six to eight additional weeks. Under "Anticipated Loss" he may note that post-traumatic arthritis and nonunion of the medial malleolus are complications.

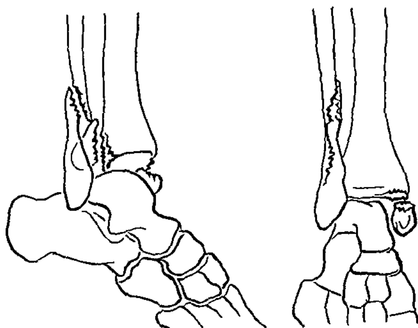


Fig. 104.—Lateral and anteroposterior views of a trimalleolar fracture of the ankle. Note the fragment from the posterior aspect of the tibia as seen in the lateral view in addition to the fractures of the lateral and of the medial malleoli.

Trimalleolar Fracture-Dislocation of the Ankle.—A continuation of the same type of violence responsible for a trimalleolar fracture may result in a trimalleolar fracture with the addition of a posterior dislocation of the talus from the ankle mortise. Treatment for the trimalleolar fracture-dislocation is the same in essence as for the trimalleolar fracture; that is, manipulative reduction is performed and a cast is applied. If a satisfactory position is not attained or if the fracture of the posterior malleolus involves more than one third of the articular surface, open reduction is performed.

In general, the prognosis is relatively poor because of the late development of pain in spite of a good reduction. The ankle is immobilized ordinarily for at least eight weeks, the treatment of the fracture taking precedence over the dis-

location with regard to healing time. After healing has been confirmed clinically and by x-ray pictures, gradual resumption of motion and weight-bearing is undertaken.

In filling out an insurance form the practitioner should estimate the total disability at twelve to fourteen weeks and the partial disability at six to eight additional weeks Under "Anticipated Loss" he may note that post-traumatic arthritis is common.

Post-Traumatic Arthritis of the Ankle

A fracture of the ankle has a rather poor long-term prognosis. Even when the reduction of the fragments has been excellent and despite good early healing of the fracture, the patient may complain in three or four years of a progressive disability of the ankle which manifests itself by increasing pain, swelling, and stiffness. These difficulties usually increase to such an extent that the patient is eventually badly disabled. Operative measures to relieve the pain and to allow the patient to do productive work are required. Roentgenograms will reveal the pathologic changes. (Fig. 105, A.) There is narrowing of the joint

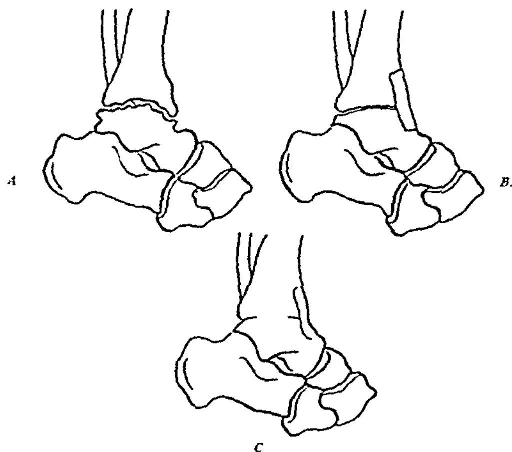


Fig 105.—*A*, Post-traumatic arthritis of the ankle. *B*, Treatment consisted of cutting away the irregular joint surfaces (arthrodesis) and placing a bone graft between the tibia and the talus anteriorly. *C*, Late follow-up reveals solid fusion of the talus to the tibia and the eradication of the ankle.

space, irregularity of the joint contour, spurs along the margins of the joint, and flattening and irregularity of that portion of the talus which fits into the ankle mortise. Clinically there is swelling around the ankle, tenderness to palpation (usually with several spots of acute tenderness scattered in various locations), palpable grating upon motion, and limitation of motion and pain upon attempted passive or active motion. Arthrodesis of the joint is the indicated procedure in treatment. (Fig. 105, *B* and *C*.)

Diastasis of the Ankle

At times, diastasis or widening of the ankle mortise occurs alone, unassociated with a fracture, (but nonetheless due to injury). At other times, it is a complicating factor in a fracture of the ankle. When the injury is acute and the x-ray pictures reveal only diastasis, it is well to apply a cast to exert a compression force on the malleoli (sufficient padding must be present to prevent pressure sores). The cast should be left on for four to six weeks.

If the condition is long standing, the patient may have various complaints. He may complain that he frequently turns or sprains the ankle, that it is "weak," or that prolonged use produces chronic pain. Examination may show a point of tenderness just anterior to the distal tibiofibular joint. Forcible inversion of the foot at the ankle may reveal that the distal fibula moves laterally away from the tibia due to the laxity of the ligaments binding the distal tibiofibular joint. Roentgenograms taken as forcible passive inversion of the ankle is instituted may be diagnostic of the condition if both clinical and conventional x-ray examinations have failed to reveal the nature of the difficulty. The conservative treatment for long-standing diastasis is the application of a strong, molded leather gauntlet cuff or brace which includes the foot, the ankle, and the distal portion of the lower leg.

Some orthopedists pin the fibula to the tibia at the distal tibiofibular joint when performing an arthrodesis of this area. (This is not to be confused with an arthrodesis of the ankle joint per se.)

Fractures of the Tarsus

Fracture of the Calcaneus.—The most commonly fractured bone in the tarsus is the calcaneus. There are numerous types, but only one will be discussed here. The history is frequently of a fall from a height with the patient landing on both feet. On inspection the region of the heel both posteriorly and on the plantar aspect is, as a rule, markedly swollen and ecchymotic. Many times there is an obvious broadening of the heel and a shift of the heel to the lateral side. The height of the malleoli from the ground may be diminished in comparison with the normal side.

The injury results in the following disturbances in the body of the calcaneus. The posterior portion of the calcaneus is driven forward, upward, and somewhat laterally. The fracture is commonly impacted, and often it involves the sub-

astragalar joint. The heel is flattened and broadened, the arch of the foot is lowered, and a portion of the calcaneus frequently lies beneath the lateral malleolus. The malleoli themselves are nearer the ground than is normal.

Reduction must accomplish the following objectives: (1) break up the impaction, (2) restore the gentle, normal arch to the calcaneus, (3) swing the calcaneus downward and medially away from the lateral malleolus, and (4) restore the subastragalar joint. Boehler has indicated an angle which is very useful in judging the efficiency of a reduction. Examine the lateral appearance of the normal calcaneus. The bone is gently arched so that the subastragalar joint is its highest point. Draw a line along the superior aspect of the tuberous portion of the calcaneus, and extend it anteriorly. Then draw a line parallel with the

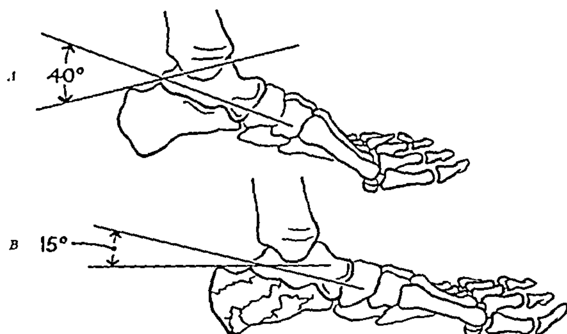


Fig. 106.—*A* illustrates the normal tuber-joint angle. *B* illustrates the diminution of the tuber-joint angle in fractures of the calcaneus.

plane of the subastragalar joint, and extend it posteriorly. These two lines normally form an angle of about 40 degrees, called the tuber-joint angle. (Fig. 106, *A*.) In a fracture of the calcaneus, this angle is decreased or at times even reversed. (Fig. 106, *B*.) Reduction attempts to reconstitute this angle, among other objectives.

Reduction is carried out by several maneuvers. The impaction is broken up by immobilizing the ankle, grasping the heel firmly, and rocking it from side to side forcibly. Then the sides of the calcaneus are compressed with a clamp. This overcomes the broadening of the heel. A Steinmann pin is inserted through the posterior calcaneal fragment and incorporated into the cast while traction is being exerted upon it. The posterior fragment is thus pulled downward while pressure is exerted upward at about the mid-point of the calcaneus. This reconstitutes the gentle arch of the calcaneus and the foot. The cast is applied from

above the knee (which is in moderate flexion to relax the Achilles tendon) downward over the inverted foot and molded into the longitudinal arch. The inversion aids in pulling the calcaneus downward and away from the lateral malleolus. If the reduction has been successful, the subastragalar joint is well formed. However, a frequent complication is that this joint heals irregularly and produces a painful and disabling traumatic arthritis of the subastragalar joint. Arthrodesis of the subastragalar joint might be necessary to relieve this condition. Immobilization for about eight weeks is necessary for a fresh fracture of the calcaneus to heal.

There are other methods of treatment of a fracture of the calcaneus. Some orthopedists advise bed rest, without any attempt at reduction. The rationale for this procedure is that there will be a natural ankylosis of the subastragalar joint which will replace any subastragalar arthrodesis required later if disabling arthritis results. This method of treatment is not recommended, since the condition of the subastragalar joint is not the only consideration in a fracture of the os calcis. One must also remember that the lateral side of the calcaneus might impinge upon the distal fibula if the fracture remains unreduced. In addition, the alignment of the foot as a whole, in regard to inversion and eversion and pronation of the longitudinal arch, may also be dependent upon the adequacy of the reduction of a fracture of the calcaneus. Furthermore, a natural ankylosis of the subastragalar joint does not necessarily follow a fracture of the os calcis. For these reasons we do not recommend that the patient simply be placed at bed rest without any attempt at reduction of the fracture.

Other orthopedists believe that emphasis must be placed upon the status of the subastragalar joint. Therefore, a primary subastragalar arthrodesis is performed, rather than a reduction of the fracture of the os calcis. The reason for such a procedure is that the possibility of pain due to subastragalar incongruity and subtalar arthritis is so great following a fracture of the calcaneus that the arthrodesis will become necessary sooner or later. Possibly, if the subtalar joint is obviously very badly damaged and beyond hope of reconstitution by a skillful reduction, primary subastragalar arthrodesis would, in fact, be the method of choice.

In filling out an insurance form the practitioner should estimate the total disability at fourteen to sixteen weeks and the partial disability at six to eight additional weeks. Under "Anticipated Loss" he may note that subtalar arthritis is common and that there may be a loss of inversion and eversion of the foot.

Fracture of the Neck of the Talus.—Rarely, a fracture extends through the neck of the talus. There may or may not be displacement of the head. The fracture is somewhat analagous to a fracture of the neck of the femur; that is, it cuts off the blood supply to the distal (head) portion. Therefore, nonunion of the fracture and aseptic necrosis of the head of the talus are likely to occur.

Treatment consists of adequate reduction and close approximation of the fragments (open reduction is often used) and the application of a cast. If open reduction is used, internal fixation is often employed also.

astragalar joint. The heel is flattened and broadened, the arch of the foot is lowered, and a portion of the calcaneus frequently lies beneath the lateral malleolus. The malleoli themselves are nearer the ground than is normal.

Reduction must accomplish the following objectives: (1) break up the impaction, (2) restore the gentle, normal arch to the calcaneus, (3) swing the calcaneus downward and medially away from the lateral malleolus, and (4) restore the subastragalar joint. Boehler has indicated an angle which is very useful in judging the efficiency of a reduction. Examine the lateral appearance of the normal calcaneus. The bone is gently arched so that the subastragalar joint is its highest point. Draw a line along the superior aspect of the tuberous portion of the calcaneus, and extend it anteriorly. Then draw a line parallel with the

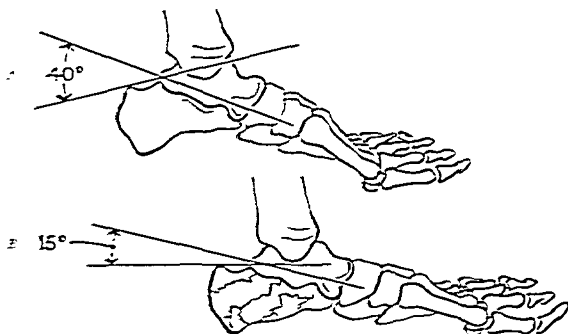


Fig. 106.—A illustrates the normal tuber-joint angle. B illustrates the diminution of the tuber-joint angle in fractures of the calcaneus.

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shoe, such as a ski boot, is all the treatment required. The stiff sole prevents motion at the fracture site and thus prevents pain. The great toe is especially vulnerable to injury. Occasionally, open reduction is required. It is used if displacement of the fragments of the hallux is marked, since the great toe is of importance in weight-bearing.

In general, it is noted that a fracture of a phalanx is managed better if the toe is not strapped with adhesive. Since strapping usually causes the toe to throb and gives the patient no comfort, it is of no special value in the treatment of the fracture. Furthermore, it is a good policy for the patient to spare the foot as much as possible, to elevate it over prolonged periods, and to apply ice bags. When an acute fracture of the great toe occurs, drilling of the nail in order to relieve a subungual hematoma ordinarily gives marked relief from pain.

In filling out an insurance form the practitioner should estimate the total disability at two weeks and the partial disability at two additional weeks. Under "Anticipated Loss" he may note that very rarely is there any permanent partial loss of function.

Sprained Ankle

An exceedingly common injury to the ankle is the so-called sprained ankle. In this injury the ankle has been forcibly twisted in either eversion or inversion—usually in marked inversion of the foot at the ankle. As a result the lateral collateral ligament of the ankle stretches or tears. The patient complains of pain, limps badly because of the pain, and may indeed be unable to bear weight on the injured extremity. During examination the practitioner should decide, if possible, whether the injury is a sprain or a fracture. Some of the clinical points of differentiation follow.

In a fracture the tenderness is directly over the bone, that is, over the distal fibula itself or the medial malleolus itself. In a sprain the tenderness is actually over either the origin or insertion of the collateral ligament. Most commonly the lateral collateral ligament of the ankle is involved, and tenderness is present just below the distal end of the fibula, over the lateral aspect of the foot, and anterior to the ankle joint. Often tenderness is present in the anterolateral fat pad in front of the fibula and not over the body of the fibula. Furthermore, ligamentous strain or tear produces pain when the ligament is stretched. Therefore, in a sprain, inversion of the ankle by the examiner is likely to cause pain in the lateral aspect of the foot if the lateral collateral ligament is sprained. In a fracture of the lateral malleolus, the maneuver of inversion is not particularly painful. On the other hand, eversion of the foot by the examiner in a sprain of the lateral collateral ligament is not particularly painful, whereas in a fracture of the lateral malleolus it is painful. These same principles obtain in the reverse circumstance of either a fracture of the medial malleolus or a sprain of the medial collateral ligament of the ankle.

While the practitioner should attempt to decide whether the injury is a sprain or a fracture by his understanding of the clinical differentiation just described, nonetheless, he should also take an x-ray picture to confirm his opinion. In a sprained ankle, the x-ray picture may be negative or may reveal only soft tissue swelling, of which the examiner was aware as a result of his clinical examina-

In filling out an insurance form the practitioner should estimate the total disability at twelve to fourteen weeks and the partial disability at four to six additional weeks. Under "Anticipated Loss" he may note that nonunion is common.

Fractures of the Metatarsals

Fractures of the metatarsals are comparable to those of the metacarpals. Reduction by manipulation is usually possible, and a plaster boot is applied until healing has taken place (four to five weeks). Fracture of the proximal portion of the fifth metatarsal deserves special mention. The peroneus brevis muscle inserts at this site. Therefore, the muscle pull is likely to displace the fragment if *the cast is removed too soon. Hence, a week or two longer is needed for healing* to occur.

In filling out an insurance form the practitioner should estimate the total disability at six to eight weeks and the partial disability at two to four additional weeks. Under "Anticipated Loss" he may note that no permanent partial loss of function should be anticipated.

March Fracture.—Much has been written about a special kind of fracture which occurs most frequently in the metatarsals, although other bones are subject to the same type of break. It is the so-called march fracture, fatigue, or insufficiency fracture. This occurs supposedly as a result of repeated minimal trauma to a foot not accustomed to the stress of strenuous work, to a foot mechanically inadequate, or to a foot whose bones are not sufficiently strong to bear exceptional stress. Fatigue or insufficiency fractures were especially common among the members of the Armed Services during World War II. In many instances, when a man who had led a relatively sedentary existence was suddenly forced to assume a rigorous military life, including long marches, the structure of the bones of his feet proved to be inadequate to meet the increased stress. During or after a long march, sudden pain would occur in the foot. Since roentgenograms taken at the time were negative, it was supposed that no fracture existed. However, pain and disability would continue and increase. Roentgeonograms taken three or four weeks later would reveal a small fissure in the cortex of a bone, usually a metatarsal, and a small globule of callus around the fissure. Hence, it was postulated that the bones in the foot had been inadequate to withstand the sudden strain of a forced march, and a small fissure fracture, which did not show up on the roentgenogram until callus had formed, had resulted. Thus, the characteristics of a march or insufficiency fracture are absence of a specific trauma adequate to cause a fracture, negative roentgenograms at first, and indication of the fracture, usually, by the appearance of callus after three of four weeks.

Treatment consists of incorporating a special metal device into the sole of the shoe to prevent it from bending.

Fractures of the Phalanges of the Toes

The phalanges of the toes may be fractured as a result of dropping a heavy object on the foot or stubbing the toes. Frequently, the wearing of a stiff-sole

In filling out an insurance form the practitioner should estimate the total disability at two to four weeks and the partial disability at two to four additional weeks. Under "Anticipated Loss" he may note that no permanent partial loss of function should be anticipated.

Post-Traumatic Spastic Valgus Deformity of the Foot and Ankle

Upon rare occasions, following either a fracture or a sprain of the ankle, the patient may complain that the foot is painful and appears to be deformed. Upon inspection, the practitioner may at first believe that a sudden accident has produced a fracture at the site of a previous fracture. Examination reveals that the forefoot is held in abduction and that the long arch is depressed. The whole foot will seem to be in marked pronation. However, x-ray pictures will reveal that the old fracture is indeed well healed and that no deformity has occurred at the fracture site. If the practitioner knows that the original injury was simply a sprained ankle and not a fracture, this painful deformity of the foot will appear at first rather difficult to understand Further examination will reveal that actually muscle spasm is holding the foot in the position of valgus, and an attempt to bring the foot into normal position is painful.

Treatment of the condition consists of a series of lumbar sympathetic blocks, which relieve the pain, allow the spasticity to disappear, and permit the foot to return to its normal position.

NONTRAUMATIC DISORDERS OF THE FOOT

Complaint	Likely Diagnoses	Page
Calluses on toe Painful toe	(1) Hammer toe	180
Pain in great toe severe enough to prevent walking Pain around great toe	(1) Hallux rigidus (2) Bunion (Hallux valgus)	180 181
Pain around fifth metatarsal head	(1) Bunionette (bunion of fifth metatarsal head)	183
Pain underlying metatarsal head Pain underlying metatarsal head, radiating to a toe	(1) Fallen metatarsal arch (2) Morton's toe (anterior metatarsalgia)	183 183
Ache in feet and/or calves	(1) Pronation of foot	184
Pain in foot medial to scaphoid bone	(1) Accessory scaphoid bone	185
Painful lump on dorsum of foot	(1) Hypertrophic changes in first metatarsal base and associated adventitious bursitis	186

(Continued on next page)

tion. The rationale of treatment depends upon a simple principle. In a sprained ankle the collateral ligaments (which are, after all, soft tissue structures) have been injured. Since the ligamentous structures of the body require about two weeks to heal, it seems medically sound to immoblize the area of the sprained ligament and to spare the ligament its normal supporting function for at least two weeks. Therefore, the recommended treatment consists of strapping the foot and ankle with an elastoplast bandage. Before the bandage is applied, the injured area should be shaved and painted with a compound tincture of benzoin. Furthermore, frequent elevation of the part, together with the application of an ice bag, aids in reducing and minimizing the hematoma and swelling which are likely to occur In addition, the foot and ankle should be used to bear weight only in a very restricted sense during the first three or four days following a sprain. In restricting the activities of the patient, the practitioner must, of course, exercise judgment in determining the severity of the injury. During the two weeks of immobilization, the patient may gradually become more active, and he should use the foot and ankle to bear progressively more weight. At the end of two weeks the elastoplast bandage is removed, and the ankle is re-examined. If some swelling and some areas of tenderness over the ligamentous structures still persist (for example, just below the fibula and over the lateral aspect of the foot), then a second elastoplast bandage is applied for an additional ten to fourteen days. At the end of this time, it is removed. The ankle will probably be sufficiently well recovered for the patient to wear an elastic supporting bandage, which should be removed for progressively longer periods during the following two or three weeks. The patient should be instructed to remove the bandage one hour earlier each day. In this way chronic swelling and discomfort are prevented. If an elastoplast bandage is removed suddenly and not replaced by some other type of support which can be removed gradually, the sprained ankle is likely to become chronically swollen and to give the patient considerable difficulty for a prolonged period.

To summarize, the general principles in the treatment of a sprained ankle are (1) immobilization of the ankle with a supportive bandage, such as an elastoplast, (2) frequent elevation of the ankle for two to three days, (3) application of an ice bag for the first twenty-four to forty-eight hours, (4) protection of the ankle from ordinary function for three to four days, (5) gradual progressive weight-bearing from the fourth to the fourteenth day, and (6) use of an elastic support, which is gradually removed during a two-to-three-week period, after the elastoplast bandage is removed.

Cognate to the sprained ankle is an avulsion fracture of the neck of the talus

Avulsion Fracture of the Neck of the Talus

At times, in a patient who has supposedly suffered only a sprained ankle, roentgenographic examination will reveal that a small chip of bone has been avulsed from the dorsum of the neck of the astragalus. The important factor to remember here is that the possibility of this fracture should be considered when pain persists longer than is normal in a sprained ankle. Adequate treatment usually consists of strapping the injured part.

may at first reveal nothing of an enlightening nature, but when the passive motion of the great toe is tested, it will be noted that the motion of the first metatarsophalangeal joint is markedly restricted in comparison to the motion of the great toe on the normal foot. It may also be possible to palpate an enlarged first metatarsophalangeal joint. The diagnosis in such instances is probably hallux rigidus, which is essentially hypertrophic changes at the first metatarsophalangeal joint, more or less localized in this area. X-rays pictures, of course, help confirm the clinical impression. It is an extremely disabling condition.

Treatment consists of performing an arthroplasty upon the joint. The distal metatarsal is smoothed, and the fascia is interposed. The Keller operation (described under Hallux Valgus) is also a possible method of treatment.

Bunion (Hallux Valgus)

In this same region of the great toe, an identical complaint is made that the first metatarsophalangeal joint is so sore as to make weight-bearing and walking almost impossible. Examination may reveal that the great toe has shifted laterally and that the distal portion of the metatarsal bone is hypertrophied and enlarged. The skin over the area is reddened, and there is moderate to marked tenderness to palpation. The motion of this joint is likewise restricted. The condition is, of course, hallux valgus, commonly called bunion. The only essential difference between hallux rigidus and hallux valgus is that in the latter the great toe has shifted to a lateral position (the position of valgus) and a subcutaneous bursa has developed over the hypertrophied distal end of the first metatarsal bone. (Fig. 108.) As the bursa becomes irritated, the patient experiences pain. Hallux valgus usually occurs in persons who have a short first metatarsal or metatarsus primus atavicus. X-ray pictures, of course, confirm the diagnosis.

Numerous operative methods are used in the treatment of hallux valgus. The McBride, Mayo, Keller, and Lapidus operations will be described briefly.

In the *McBride operation* an incision is made over the medial aspect of the extensor hallucis longus. The intrinsic adductor tendon is detached from the lateral surface of the base of the proximal phalanx of the great toe and is transplanted to the lateral side of the distal portion of the first metatarsal. The hypertrophic bone on the medial side of the first metatarsal is removed. It can be seen that by a transference of muscle pull, the metatarsal is moved laterally to allow the great toe to swing medially.

In the *Mayo operation* an incision is made over the medial aspect of the metatarsophalangeal joint. The bursa is saved in a flap. The hypertrophied portion and most of the head are excised The flap containing the bursa is then interposed between the metatarsal and the phalanx In this type of arthroplasty the bursa is used to maintain a movable metatarsophalangeal joint.

In the *Keller operation* the incision is made over the medial aspect of the metatarsophalangeal joint. The prominence of the distal metatarsal (medial aspect) is excised. A portion of the proximal phalanx of the great toe is excised; that portion should be great enough that overcorrection of the deformity can be

Complaint	Likely Diagnoses	Page
Instep is high Toes are cockedup	(1) Clawfoot (Cavus)	186
Painful heel	(1) Calcaneal spur	188
	(2) Achilles bursitis	189
Weakness and/or deformity of foot and ankle	(1) Post-poliomyelitic deformities	189
Walks on tiptoe	(1) Cerebral palsy (spastic paralysis)	190

Hammertoe

One common complaint is that of a painful corn on the dorsum of the toe. Inspection reveals that the fundamental difficulty is hammertoe. In this condition the toe is acutely flexed at the proximal interphalangeal joint, and it may be extended at the metatarsophalangeal joint. Consequently, painful calluses develop on the dorsum of the interphalangeal joint and also on the very tip of the toe, which has been pushed down against the sole of the shoe. (Fig. 107.)

Conservative therapy, consisting of placing an innersole with a metatarsal button in the shoe, may provide relief, particularly if the condition is not advanced. However, conservative therapy is, in general, not so effective as operative therapy. Correction consists of operative excision of the proximal interphalangeal joint, which allows the toe to assume a more normal position and prevents the shoe from pressing on the dorsum of the interphalangeal joint and the tip of the toe.

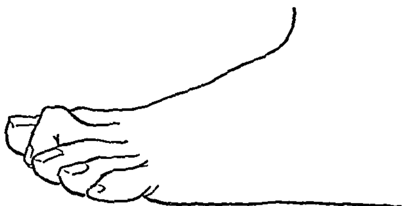


Fig. 107.—Hammertoe A corn usually forms on the top and the end of the toe (From Larson, C. B , and Gould, M Calderwood's Orthopedic Nursing, 1957, The C V. Mosby Co.)

Hallux Rigidus

The presenting complaint may be that of pain upon walking which is localized in the first metatarsophalangeal joint of the great toe. Inspection of this area

mainder, fair results are obtained or the condition is not improved. Many times it takes several months for the pain to disappear in patients who eventually are considered to have obtained good results from operation.

Conservative measures in the treatment of hallux valgus are several. The area of the shoe over the bunion can be either cut out or markedly softened. A doughnut-shaped piece of felt is at times used to remove the pressure of the shoe from the irritated area. As a preventive measure, an innersole in the shoe, with an extension supporting the undersurface of the first metatarsal, is occasionally used.

Bunionette (Bunion of Fifth Metatarsal Head)

At times a complaint of pain and swelling of the distal end of the fifth metatarsal bone is encountered. Inspection reveals a reddened, enlarged fifth metatarsal head, with a bursa under the skin. This is called a bunionette. The mechanism producing this condition in the fifth metatarsal head is quite similar to that producing hallux valgus in the first metatarsal head.

Conservative treatment consists of relieving pressure over the area by prescribing an especially made shoe in which the lining of that part of the shoe over the bunionette is particularly soft or by applying a small, felt, doughnut-shaped ring to keep the shoe from pressing on the tender, enlarged fifth metatarsal head. If the process is uncontrollable by these means and if the patient is sufficiently disabled, operative correction consisting of excision of all hypertrophic bone on the fifth metatarsal head should be performed.

Fallen Metatarsal Arch

Frequently, one (or more) of the heads of the metatarsals descends below the level of its fellows. Thus, it must bear more weight than it normally should. Consequently, a painful callus develops over the distal end of the fallen metatarsal bone. High-heeled shoes aggravate the condition and may also be one of the etiologic factors. The patient, usually a woman, complains of pain in the "ball of the foot," stating that is feels as if the weight is being borne by an individual bone or as if a marble has been placed underneath the foot in this location. Examination reveals a tender callosity on the plantar aspect of the foot over the affected metatarsal (usually the third or the second, third, and fourth). The diagnosis is a depressed metatarsal arch.

Treatment is conservative, using an innersole in the shoe with a rubber pad placed just posterior to the callus. The pad elevates the depressed metatarsal bone and distributes the weight evenly.

Morton's Toe (Anterior Metatarsalgia)

Morton's toe is a clinical entity characterized by a sharp, sudden attack of pain in the metatarsal arch with radiation of the pain to one of the toes. This pain is so sudden and so severe and sharp that the patient often volunteers the information that she must remove the shoe regardless of where she may be. Upon examination, usually no callus is found on the inferior surface of the foot,

easily obtained. Then, the capsule is closed from side to side so that soft tissue is interposed between the raw proximal phalanx and the distal metatarsal.

This operation combines the correction of the deformity by procedures on the bone and the performance of an arthroplasty of sorts. We prefer the Keller procedure.

In the *Lapidus operation* two incisions are made, one over the dorsal aspect of the proximal first metatarsal and the other over the medial aspect of the distal first metatarsal. Through the first incision fusion between the cuneiform and the first metatarsal and between the bases of the first and second metatarsals is accomplished. The soft tissues around the first metatarsophalangeal joints are managed as follows. The adductor tendon and the lateral joint capsule are tenotomized if necessary. A suture extending from the plantar and lateral aspect

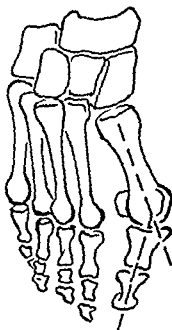


Fig. 108.—Hallux valgus. Note lateral shift of the great toe and prominence medially of the first metatarsal head.

of the toe to the proximal and medial aspect of the capsule of the first metatarsophalangeal joint is made. In this way the valgus and rotation of the great toe are corrected. A tongue-shaped medial capsular flap is resutured to aid in bringing the great toe medially. The purpose of the Lapidus procedure is to correct the metatarsus primus activicus, since sufficient bone is resected at the time of fusion to allow a more normal position of that metatarsal.

Following many of the operative procedures just described, a plaster slipper is applied. The slipper is shaped so as to hold the great toe in a position of correction. After the wound is healed, passive exercises and stretching of the toe are instituted to aid in obtaining an eventual good result. In general, good results are obtained in about 85 per cent of the patients operated upon for hallux valgus. In about 2 per cent, the condition is worse after operation. *In the re-*

thumb of the hand has an interval for grasping). The foot is thrown into pronation in order for the weight distribution upon the first metatarsal to approach the normal ratio.

Accessory bones occur in the foot as elsewhere. One of these is the accessory scaphoid bone, or the prehallux. When it is present, it is located medial to the normal scaphoid. The tendon of the tibialis posterior encloses the accessory scaphoid bone, and, therefore, the tendon is diverted from its normal course. The medial border of the foot and the longitudinal arch have thus been deprived of one of their musculotendinous supports. Consequently, the longitudinal arch becomes depressed and pronation results.

A short Achilles tendon has the effect of holding the calcaneus inclined at an angle downward, and medially, and pronation of the foot ensues.

Ordinarily, conservative therapy is satisfactory in the management of the pronated foot. An innersole with a rubber lift shaped to conform to the normal longitudinal arch can be placed in the shoe. Some recommend that this pad be placed in the region of the sustentaculum tali in order to correct the eversion of the calcaneus, and thereby overcome the pronation. Others believe that placing the lift with its greatest height underneath the scaphoid bone gives excellent results. Some orthopedists use an innersole made of metal, or of leather with a metal support. We prefer a rubber innersole covered with leather because we believe that a metal plate is too rigid. An alternative to the use of an innersole is correction on the outside of the shoe. A Thomas heel may be prescribed for some patients. It is constructed so that its medial aspect is higher than its lateral, and so that the medial aspect extends considerably farther forward than the lateral aspect. In this way the shoe is lifted upward medially, with more support underneath the longitudinal arch. Some patients find this method most satisfactory, especially if they object to an innersole.

Operative measures are used if conservative means fail The Kidner procedure is used to correct flatfoot when an accessory scaphoid is presumably the underlying fault. In this procedure the accessory scaphoid is removed, and the tendon of the tibialis posterior is transplanted to underlie the scaphoid, restoring normal support to the longitudinal arch. Various types of arthrodesis can be performed, such as fusion between the scaphoid, medial cuneiform, and first metatarsal bones (Miller operation), fusion between the scaphoid and two cuneiform bones (Hoke operation), or arthrodesis of the astragaloscaphoid joint (Lowman-Soule operation). We have been very poorly impressed with the small series of patients we have seen in whom arthrodesis was performed to correct pronation (this excepts the Kidner procedure, which is not an arthrodesis). Long and careful consideration should be given before operative measures of any of the types of arthrodesis are used to treat pronation of the foot.

Accessory Scaphoid Bone

Occasionally a patient presents with a complaint which is not due primarily to foot imbalance, but rather to local pressure of the shoe upon a bony prominence. Palpation may reveal a movable accessory bone in the involved area. The accessory scaphoid bone is situated medial to the scaphoid bone of the foot.

and compression of the foot from side to side brings on the pain. The cause for the attack of pain is a neurofibroma of the metatarsal nerve (situated between the metatarsal heads) just before the bifurcation of the nerve to supply the digital nerves of the toe.

Consequently, conservative treatment in the form of a metatarsal button placed in the shoe to elevate the metatarsal heads and spread them somewhat may at times be successful. Usually, however, surgical treatment is better ard consists of operative excision of the neurofibroma.

Pronation of the Foot

One of the numerous postural disturbances is pronation of the foot. The pronated foot is easily recognized. The calcaneus rolls outward; that is, if the left heel is viewed from the back to the front, the calcaneus is rolled in a clockwise direction; and if the right heel is viewed from behind, the calcaneus is rolled in a counterclockwise direction. Thus, the Achilles tendon bows abnormally. Furthermore, the longitudinal arch is depressed on the medial side in the region of the scaphoid bone, which may be unduly prominent. The forefoot tends to be held in abduction. Clinically, numerous complaints are characteristic. The feet may "ache all over." The region of the scaphoid bone may be pointed out as the area of pain. Ache and pain in the calves or even the low back may be the presenting complaint. On the other hand, pronation may be asymptomatic, and the complaint may be that of awkwardness of gait or of stumbling too easily. Examination may reveal some tenderness underneath the long arch of the foot.

Several structural defects can be the fundamental cause of pronation of the foot. Of these, special attention is given to (1) a short first metatarsal bone, (2) a hypermobile first metatarsal segment, (3) metatarsus primus atavicus, (4) an accessory scaphoid bone, and (5) a short Achilles tendon. The manner in which these structural defects produce pronation of the foot will be reviewed briefly.

Body weight is distributed equally upon the heads of each metatarsal except the first. The first metatarsal bears twice the weight that any other carries. Hence, it is of prime importance to foot function. If this bone is shorter than normal, it can bear its full share of the body weight only if it passes medially or if the foot is pronated. Thus, when the first metatarsal bone is short, pronation ensues

Likewise, if the whole first metatarsal segment (composed of the medial cuneiform and first metatarsal bones) is hypermobile, it cannot assume its burden of the body weight unless the foot pronates. As weight is borne on the foot, the hypermobile first metatarsal segment moves to the dorsum of the foot and fails to support the medial side. The longitudinal arch is thereby depressed, and pronation ensues.

Metatarsus primus atavicus is perhaps an attempt to revert to the prehensile (grasping) foot. In this condition the first metatarsal is shorter than normal and has migrated medially. Commonly, an unusually large interval exists between the great and the second toe, as if it were to be used for grasping (much as the

thumb of the hand has an interval for grasping). The foot is thrown into pronation in order for the weight distribution upon the first metatarsal to approach the normal ratio.

Accessory bones occur in the foot as elsewhere. One of these is the accessory scaphoid bone, or the prehallux. When it is present, it is located medial to the normal scaphoid. The tendon of the tibialis posterior encloses the accessory scaphoid bone, and, therefore, the tendon is diverted from its normal course. The medial border of the foot and the longitudinal arch have thus been deprived of one of their musculotendinous supports. Consequently, the longitudinal arch becomes depressed and pronation results.

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Pressure from the shoe causes redness and tenderness in this area. X-ray pictures will confirm the diagnosis.

Conservative therapy to relieve pressure on the area consists of elevation of the long arch by placing an innersole in the shoe in such a manner as to cause the accessory scaphoid bone to become less prominent or of the application of a doughnut-shaped, felt ring to keep the shoe away from the accessory scaphoid bone. Operative therapy, in which excision of the scaphoid bone is carried out, is relatively simple.

Hypertrophic Changes in the First Metatarsal Base and Associated Adventitious Bursitis

Another complaint associated with the long arch occurs on the dorsum of the foot in the region of the base of the first metatarsal bone. It is not uncommon for the base of the first metatarsal bone to be rough, irregular, and unduly prominent. As a result of pressure from the tongue of the shoe, an overlying adventitious bursa forms which is tender to touch. The presence of an area of redness and prominence of the irregular first metatarsal base are sufficient to establish the diagnosis.

Conservative treatment, which is usually successful, consists of padding the tongue of the shoe especially well with felt or of using a doughnut-shaped, felt ring to relieve the pressure on the hypertrophied bone.

Clawfoot (Cavus)

Occasionally a patient complains that the instep is too high, in which case clawfoot, or cavus, is suspected. Cockup of the toes is likely to be associated with this condition. Clawfoot has several characteristic features. The longitudinal arch is exaggerated and increased in height. (Fig. 109.) There is a contraction of the plantar fascia, and the length of the foot from the heel to the toes is diminished Often the heads of the metatarsals are depressed so that large, painful, and even disabling callosities may develop on the plantar aspect over the prominent metatarsal heads The toes are usually subluxated at the metatarsophalangeal joints The proximal interphalangeal joints are flexed, but the distal interphalangeal joints are extended, as a rule. Such a deformity of the toes might conceivably be a result of contracture of the long extensor and long flexor muscles.

The etiology of clawfoot is not clear Suffice it to say that it may be either congenital or acquired. If acquired, it is believed by many to be a result of muscle imbalance due to previous anterior poliomyelitis For example, if the muscles which depress the longitudinal arch are weaker than the muscles which elevate the longitudinal arch, it is conceivable that cavus could develop. As an illustration, assume that the tibialis anticus and the extensor digitorum longus muscles are weaker than the posterior tibial and the short flexor muscles of the toes. The distal ends of the metatarsals will be depressed A contracture of the plantar fascia might follow, leading thus to pes cavus

The conservative treatment consists of placing an innersole in the shoe, with both a longitudinal arch and a transverse metatarsal bar The long arch of the innersole helps to distribute the weight more evenly by actually coming in

contact with the cavus part of the deformity. The transverse metatarsal bar is used to force the cockup position of the toes into a more normal position. Sometimes the conservative treatment is successful in maintaining the patient in a reasonably comfortable state. However, if the conservative measures fail, operative measures should be performed.

One of the best known operative procedures is the stripping of the plantar fascia, as performed by Steindler. An incision is made on the medial aspect of the foot at about the junction of the thick skin of the sole and the soft skin of the side of the foot. By sharp dissection, the origin of the plantar fascia, the abductor hallucis, and the abductor digiti quinti are uncovered. These structures are then either stripped from the calcaneus or severed near their origins. The deformity is then corrected, and a cast is applied.



Fig. 109.—Clawfoot deformity with retraction of the toes and high arch (cavus). (From Larson, C. B., and Gould, M : Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co)

The Steindler procedure is perhaps most successful in children. In the treatment of adolescents or adults, many orthopedists prefer to supplement the Steindler operation by other procedures. In one such operation all five extensor tendons are transplanted into the heads of the metatarsals, sometimes into the bases of the metatarsals, or even into the cuneiform bones. Capsulotomy of the metatarsophalangeal joints and arthrodesis of the interphalangeal joint of the great toe are also frequently used to aid in the correction of the cavus foot with clawtoe when tendon transplantation has been done. The reasons for these additional procedures should be clear. The extensor tendons of the toes are cut and transplanted because contracture of the extensor tendons is believed to be one of the causes of cockup of the toes. The arthrodesis of the interphalan-

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widely injected with Novocain. Then repeated applications of diathermy directed to the sole of the foot should be carried out. Some spurs are resistant to any type of conservative therapy. Calcaneal spurs more commonly occur in the older person, but rarely they occur even in the adolescent. The cause of the spurs is not clear, although a relationship with the rheumatic fever diathesis has been hypothecated.

Achilles Bursitis

A complaint of pain in the heel at the junction of the Achilles tendon with the os calcis suggests Achilles bursitis. Several small bursae occur around the distal portion of the Achilles tendon. One of these lies between the skin and the tendon, and another underlies the tendon. The skin may be thickened and reddened, local swelling may be present, there will probably be tenderness to palpation, and frequently the patient will state that he recently acquired a new pair of shoes. The hard counter of the heel of the new shoe rubbed the area where the Achilles tendon joins the os calcis, forming an adventitious subcutaneous bursa.

Treatment, which is conservative, consists of using a heel lift in the shoe so that the shoe does not rub the inflamed area or of removing the hard counter in the heel of the shoe.

Post-Poliomyelitic Deformities*

Many types of muscle weakness and consequent disabilities and deformities develop as a result of anterior poliomyelitis. Only certain general principles will be pointed out here. If the patient is in the convalescent stage of anterior poliomyelitis, physical therapy in the form of muscle re-education and active exercises graduated to active resistive exercises should be employed at first. In this way the patient is helped to regain naturally all of the muscle power of which he is capable However, if a patient has had poliomyelitis at some time in the past, then the principles of treatment will depend upon the specific condition.

One of the common conditions is weakness in dorsiflexion of the foot at the ankle (foot drop) In this circumstance, a brace can be employed. It may be constructed so that the ankle can be locked at any desired degree to prevent the foot from falling into the foot-drop position at each step. Moreover, the brace may be a spring type which actually helps to dorsiflex the foot during gait. If bracing is not desirable, operative measures consisting of the transference of the muscle and tendon systems can be carried out. The powerful peroneus longus might be suitable to transfer to a weakened tibialis anterior in order to achieve more powerful dorsiflexion in the foot during gait.

Instead of foot drop, the reverse condition, due to weakness of the gastrocnemius soleus group, may be present. In this condition the patient has a flatfooted gait and is unable to rise to tiptoe during normal gait. Under such

*Refer to the discussion of Post Poliomyelitic Deformities of the Foot and Ankle (page 53) in Chapter 1, Diseases or Affections in Childhood, for a fuller discussion of this subject.

geal joint of the great toe is performed to prevent uncontrollable motion of this toe when a shoe is put on (since the extensor tendon has been cut). The dorsal capsulotomy of the metatarsophalangeal joints is performed to allow correction of the dorsal subluxation at these joints when the extensor tendons have been transplanted. *In a long-standing* or severe condition operation upon the bone may be necessary. If so, usually a wedge of bone is removed from the midtarsal region with its base dorsally so as to allow depression of the abnormally high longitudinal arch.

Calcaneal Spur

When a patient's complaint involves the plantar aspect of the heel, tenderness can be found to be very sharply localized to the plantar aspect of the os calcis at about the level of three or four fingerbreadths forward from the end of

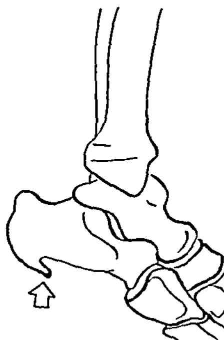


Fig 110 —*Calcaneal spur*

the heel. Tenderness may also be found on the lateral and medial sides of the foot at this same level. The practitioner should, of course, suspect that the cause *of the discomfort is a calcaneal spur. X-ray pictures will confirm the diagnosis.* A bone spur can at times result in disabling pain. (Fig. 110.)

Many patients are successfully treated by the use of a sponge rubber pad or a lift constructed in such a manner as to relieve pressure on the area. At times the pain and disability warrant operative intervention. The spur is removed through an incision similar to that used in the Steindler operation for stripping of the plantar fascia. (See under Clawfoot [Cavus].) Nonetheless, results from operative intervention are many times very disappointing. Conservative therapy should be given a thorough trial. It is suggested that the region of the spur be

Chapter Four

*Disturbances of the Knee in the Adult**

ANATOMY

The knee joint is an exceedingly complex articulation. It is frequently the site of injury or mechanical derangement, and injury to the knee can cause great disability. Essentially, the knee is three joints in one; that is, there is articulation between the patella and the anterior femur and between each of the femoral condyles and the corresponding tibial condyle. Certain characteristics of the anatomy of the knee should be reviewed. Anteriorly, the four bellies of the quadriceps femoris muscle join to form the quadriceps tendon about three inches above the superior border of the patella. The majority of the tendon passes anterior to the patella, becomes the patellar ligament at the inferior border of the sesamoid, and inserts on the tibial tuberosity. On either side the expansion of the tendon blends with the capsule of the joint.

The patella is an oval-shaped bone carried within the tendon of the quadriceps, and the posterior surface of the patella is expanded to fit into the intercondylar groove on the femur.

The capsule of the knee has at least two important ligamentous structures, the medial and lateral collateral ligaments. (Fig. 111.) The medial collateral ligament originates just above the flaring condylar portion of the medial aspect of the femur and passes downward to attach to the medial tibial condyle. This ligament remains taut throughout most of the range of motion of which the knee is capable and therefore is of great importance in maintaining stability in the joint. The medial semilunar cartilage (to be described later) is very closely attached to the medial collateral ligament, and the importance of this relationship will be apparent when we discuss internal derangements of the knee.

The lateral collateral ligament is weaker than the medial, even though it originates and inserts on the femur and fibula analogously with the medial collateral ligament. Its tension changes with the range of motion of the knee.

The knee joint is supported anteriorly by the quadriceps tendon and the patella, posterolaterally, and posteromedially by the hamstring muscles and tendons, and posteriorly by the heads of the gastrocnemius.

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*See also Disturbances of the Knee in Infancy and Childhood (page 56) in Chapter 1, Diseases or Affections in Childhood

a circumstance, a spring brace, the reverse of that used in the treatment of foot drop, is employed to aid the patient to achieve enough power to have spring in his step.

A third common post-poliomyelitic disability of the foot is complete flail foot and ankle. Conservative therapy consists of placing a cuff around the lower leg, ankle, and foot, constructed so that it can be used inside the shoe. In addition, a relatively strong brace from the lower leg to the shoe is applied. If bracing and support are not desirable, operative means should be employed. Operation consists of a panastragalar arthrodesis; that is, stabilization of the ankle and foot by fusion of the ankle joint, the taloscaphoid joint, the subastragalar joint, and the calcaneocuboid joint.

Still another post-poliomyelitic deformity is contracture of the Achilles tendon or contracture of the Achilles tendon and the plantar fascia. Operative lengthening of the Achilles tendon and plantar fasciotomy are the operative procedures available to correct this deformity. Sometimes the post-poliomyelitic deformity is very similar in appearance to the true talipes equinovarus of the clubfoot. If this is true, bone stabilizing procedures, such as triple arthrodesis of the foot either alone or in combination with muscle tendon transference, can be performed.

To summarize treatment of post-poliomyelitic deformities and disabilities of the foot, physical therapy is used unless there is no hope that the patient can regain natural muscle power. The application of a brace is the principal conservative method of treatment, and the brace may be either static to control motion or a spring type to aid active power. Among the operative procedures available are tendon transference, arthrodesis to stabilize the bone, a combination of tendon transference and arthrodesis, tendon lengthening, and fasciotomy and capsulotomy which correct deformities due to contracture of the surrounding soft tissues.

Cerebral Palsy (Spastic Paralysis)*

Persons afflicted with spastic paralysis may walk with the foot held in equinus if the leg is involved. The conservative treatment of the spastic foot and ankle consists of repeated stretching of the heel cord, the use of a night cast applied in the corrected position, and the use of a brace during the day, either one which prevents the equinus deformity or the spring type which aids the dorsiflexion of the foot in gait. Gait training under a competent physical therapist is of help. If conservative measures are not enough, then surgical procedures are possible. One of the accepted operative procedures is neurectomy The tibial nerve is exposed in the popliteal fossa, and the branches supplying the gastrocnemius are resected At times, one branch to the soleus is resected as well. Hence, the spastic gastrocnemius, responsible for the equinus position, is relaxed, permitting an improved gait The Achilles tendon can be lengthened in preference to performing a neurectomy of the branches to the gastrocnemius. At times a triple arthrodesis, as described previously under Clubfoot (page 37) and Post-Poliomyelitic Deformity (p 53), can be performed.

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*Refer to discussion of Cerebral Palsy (page 39) under discussion of Disturbances of Foot and Ankle in Chapter 1, Diseases or Affections in Childhood, for a fuller discussion of this subject.

between the medial and lateral femoral condyles, respectively, and the joint capsule on either side of and inferior to the patella. Since the synovium is also reflected over the cruciate ligaments, these are technically outside the knee joint. Hence, the posterior portion of the knee is divided into the posteromedial and posterolateral compartments.

The semilunar cartilages (also called menisci) are two in number, the medial and the lateral. Roughly speaking, they are doughnut shaped. They are attached to the capsule of the joint around their peripheries and originate in the region of the tibial spines. As has been pointed out before, the medial semilunar cartilage is closely attached to the taut medial collateral ligament. Therefore, the motion of this meniscus is limited much more than is the motion of the lateral meniscus. As the knee is brought into flexion, the menisci tend to slide posteriorly. The function of the menisci is to deepen the cup receiving each femoral condyle and to cushion the condyles.

There are two cruciate ligaments, the anterior and the posterior. They cross in the sagittal plane, and, if they are viewed laterally, they form an "X." They extend from the posterior aspect of the intercondylar femoral notch to the region of the tibial spines. Many orthopedists believe that they control anterior and posterior gliding of the tibia on the femur.

EXAMINATION OF THE KNEE

A definite procedure is followed in orthopedic examination of the knee.

First, the knee is inspected for the presence of a normal contour. Normally the patella is prominent, and there are depressions on either side of it. The popliteal space is diamond shaped, and it is limited on the periphery by the hamstring tendons and the heads of the gastrocnemius. Usually the prominences of the femoral and tibial condyles can easily be seen. The muscles controlling the knee, especially the quadriceps, are inspected, and the circumference of the thigh and calf are measured and compared with the opposite normal side.

Second, the knee is palpated. Special attention is given to the suprapatellar bursa to determine if an effusion, tumors, or loose bodies. The quadriceps tendon is [illegible] to determine whether it is firm and intact, whether it is attached to the patella, and whether it can be moved freely from side to side over the [illegible] of the femur. The patella is palpated to ascertain that it is in a normal [illegible], that it is movable, and that it is not floating. Palpation is then [illegible] as much of the joint line as possible, both medially and laterally. [illegible] may mean a disorder of the semilunar cartilages. Tenderness [illegible] the sites of the origin and attachment of the medial and lateral [illegible] ligaments. These sites are just above the flares of the femoral [illegible] flares of the tibial condyles, both medially and laterally, [illegible] noted that these sites are quite different from those at [illegible] right over the semilunar cartilages. Pain upon pressure over [illegible] or of a collateral ligament is ordinarily associated with [illegible] The region of the tibial tuberosity (the attachment [illegible]) is palpated. Tenderness here may mean Osgood-S[illegible]

It is apparent, then, that the knee must have mobility, which is supplied by the muscles, and stability, which is supplied by both the muscles and the ligaments. The joint surfaces are fitted together in such a manner that no stability could result if it were not for the combined action of the ligaments and muscles. For example, the ankle and the elbow are fitted snugly together and have bony contours shaped in such a manner that some stability is present without any strong ligaments, but from the shape of its joint surfaces, it is obvious that the knee joint has no such stability.

The knee is lined by a synovial layer which has been called the most complex in the body. Starting on the anterior surface of the femur just above the condyles, the synovium extends upward along the anterior surface of the femur

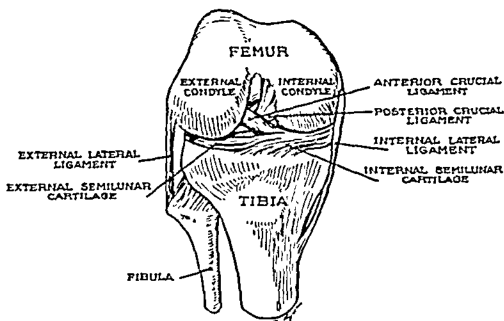


Fig 111 —Ligaments of the knee joint and semilunar cartilages shown with the knee in flexion (From Larson, C. B , and Gould, M . Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

to a level about three inches above the patella. Here, the synovium is reflected anteriorly onto the posterior surface of the quadriceps tendon and thence downward to the superior border of the patella. The synovial reflection between the quadriceps tendon and the femur forms a compartment called the suprapatellar bursa. This is simply an upward extension of the knee joint which communicates freely with the space between the tibial and femoral condyles. The synovium encircles the patella and continues downward onto the superior surfaces of the semilunar cartilages. Thence, from the inferior surfaces of these cartilages it is reflected onto the superior surface of the tibia at the periphery of the latter. These reflections of the synovium form several compartments The suprapatella is one. The anterior compartment lies between the patella and the femoral condyles. The anteromedial and anterolateral compartments are the spaces

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Second, the knee is palpated. Special attention is given to the suprapatellar bursa to detect evidence of an effusion, tumors, or loose bodies. The quadriceps tendon is inspected to determine whether it is firm and intact, whether it is attached to the patella, and whether it can be moved freely from side to side over the anterior surface of the femur. The patella is palpated to ascertain that it is in a normal position, that it is movable, and that it is not floating. Palpation is then carried out along as much of the joint line as possible, both medially and laterally. Tenderness here may mean a disorder of the semilunar cartilages. Tenderness is sought also at the sites of the origin and attachment of the medial and lateral collateral ligaments. These sites are just above the flares of the femoral condyles and below the flares of the tibial condyles, both medially and laterally, respectively. It will be noted that these sites are quite different from those at which tenderness is sought over the semilunar cartilages. Pain upon pressure over the origin and insertion of a collateral ligament is ordinarily associated with strain of this ligament. The region of the tibial tuberosity, the attachment of the extensor apparatus, is palpated. Tenderness here may mean Osgood-Schlatter's disease or prepatellar bursitis. Overlying the anteroinferior

It is apparent, then, that the knee must have mobility, which is supplied by the muscles, and stability, which is supplied by both the muscles and the ligaments. The joint surfaces are fitted together in such a manner that no stability could result if it were not for the combined action of the ligaments and muscles. For example, the ankle and the elbow are fitted snugly together and have bony contours shaped in such a manner that some stability is present without any strong ligaments, but from the shape of its joint surfaces, it is obvious that the knee joint has no such stability.

The knee is lined by a synovial layer which has been called the most complex in the body. Starting on the anterior surface of the femur just above the condyles, the synovium extends upward along the anterior surface of the femur

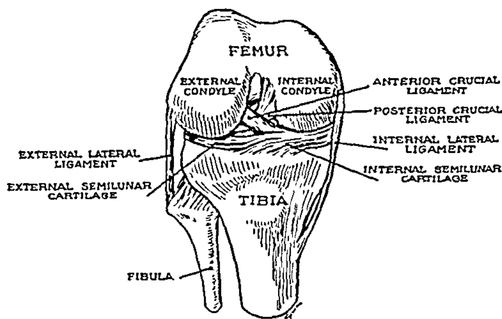


Fig 111 —Ligaments of the knee joint and semilunar cartilages shown with the knee in flexion (From Larson, C B , and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C V. Mosby Co)

to a level about three inches above the patella. Here, the synovium is reflected anteriorly onto the posterior surface of the quadriceps tendon and thence downward to the superior border of the patella. The synovial reflection between the quadriceps tendon and the femur forms a compartment called the suprapatellar bursa. This is simply an upward extension of the knee joint which communicates freely with the space between the tibial and femoral condyles. The synovium encircles the patella and continues downward onto the superior surfaces of the semilunar cartilages. Thence, from the inferior surfaces of these cartilages it is reflected onto the superior surface of the tibia at the periphery of the latter. These reflections of the synovium form several compartments. The suprapatella is one. The anterior compartment lies between the patella and the femoral condyles. The anteromedial and anterolateral compartments are the spaces

between the medial and lateral femoral condyles, respectively, and the joint capsule on either side of and inferior to the patella. Since the synovium is also reflected over the cruciate ligaments, these are technically outside the knee joint. Hence, the posterior portion of the knee is divided into the posteromedial and posterolateral compartments.

The semilunar cartilages (also called menisci) are two in number, the medial and the lateral. Roughly speaking, they are doughnut shaped. They are attached to the capsule of the joint around their peripheries and originate in the region of the tibial spines. As has been pointed out before, the medial semilunar cartilage is closely attached to the taut medial collateral ligament. Therefore, the motion of this meniscus is limited much more than is the motion of the lateral meniscus. As the knee is brought into flexion, the menisci tend to slide posteriorly. The function of the menisci is to deepen the cup receiving each femoral condyle and to cushion the condyles.

There are two cruciate ligaments, the anterior and the posterior. They cross in the sagittal plane, and, if they are viewed laterally, they form an "X." They extend from the posterior aspect of the intercondylar femoral notch to the region of the tibial spines. Many orthopedists believe that they control anterior and posterior slipping of the tibia on the femur.

EXAMINATION OF THE KNEE

A definite procedure is followed in orthopedic examination of the knee.

First, the knee is inspected for the presence of a normal contour. Normally, the patella is prominent, and there are depressions on either side of it. The popliteal space is diamond shaped, and it is limited on the periphery by the hamstring tendons and the heads of the gastrocnemius. Usually the prominences of the femoral and tibial condyles can easily be seen. The muscles controlling the knee, especially the quadriceps, are inspected, and the circumference of the thigh and calf are measured and compared with the opposite normal side.

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surface of the patella and sometimes extending below it is the prepatellar bursa. This is, of course, not to be confused with the suprapatellar bursa. The prepatellar bursa is frequently the site of an irritative, inflammatory process (acute or chronic), and localized swelling and tenderness are looked for in this region. The popliteal fossa is then palpated for evidence of Baker's cyst, aneurysm, and lipoma. Bursae not uncommonly occur in association with the hamstring tendons, such as the biceps laterally and the semimembranosus and semitendinosus medially. The region of these insertions into the tibia and fibula is palpated.

Third, the range of motion of the knee is tested for active, passive, and active resistive motion. Normally, the knee should be able to pass through an arc of 150 degrees from complete extension. This is sometimes variable, but the opposite normal knee can be used for comparison. Limitation of this normal range of flexion can result from several disorders. An effusion within the joint may limit flexion. A contracture of the extensor apparatus in either the quadriceps bellies or the tendon, or a disorder of a semilunar cartilage may limit the range of motion. A loose body in either the posterior compartment or in the suprapatellar bursa may also limit the range of motion. Intra-articular fibrous obliteration of the suprapatellar bursa, incongruity of a joint surface as a result of trauma or of hypertrophic, suppurative, or atrophic arthritis all may cause loss of flexion in the knee. Extension is normally complete; therefore, if viewed laterally, the line between the femur and tibia is straight. Inability to extend the knee completely is very commonly due to a tear or dislocation of the medial semilunar cartilage. Limitation of extension is, of course, noted in a flexion contracture of the knee due to tightness of the tendons and the posterior capsule, caused by a previous poliomyelitic infection, atrophic arthritis, etc. Occasionally the range of extension is greater than normal, and the tibia rides farther forward on the femoral condyle than it should. This is known as genu recurvatum and is usually the result of abnormal use of the knee because of post-poliomyelitic weakness. The patient throws the knee into hyperextension in order to lock it and achieves stability from this motion rather than from the weakened muscles. Gradually recurvatum develops as the posterior capsule stretches.

Fourth, abduction and adduction of the tibia on the femur are tested with the knee in extension. Normally very little of such motion is present, but the affected knee should be compared with the opposite one because of individual variations. If this motion is greater than normal, then laxity of the collateral ligaments is a possibility. A previous depressed fracture of the tibial condyle may also result in an abnormal side-to-side mobility.

Fifth, the knee is flexed to 90 degrees, and the tibia is pushed and pulled backward and forward on the femur. Many orthopedists believe that this motion tests the integrity of the cruciate ligaments. Normally, a small amount of motion should be noted. Abnormal mobility is considered a positive drawer sign and usually indicates laxity of the cruciate ligament or the medial collateral ligament. After the passive motion of the knee is tested, the active range is noted, and observations are made as to whether the limitation seems due to muscle weakness, contracted soft tissues, or bony blocks Then the muscle strength is examined as the patient moves the knee against resistance from the examiner.

Sixth, the patient should be observed while walking if the examiner thinks it is feasible.

To summarize, the procedures used in orthopedic examination of the knee include inspection; palpation of certain areas, especially of the medial and lateral joint line, the tibial tuberosity, and the origin and insertion of the collateral ligament; observation of passive and active range of motion and testing of the strength of the muscles controlling the knee; and examination of the mobility of the knee laterally and in an anteroposterior plane, first with the knee extended and then with the knee flexed to a 90-degree angle.

DISTURBANCES OF THE KNEE

Disturbances of the knee in general fall into two definite categories: those associated with injury and those arising spontaneously without apparent injury or in which injury plays little part.

TRAUMATIC INJURIES TO THE KNEE

Complaint	Likely Diagnoses	Page
Pain and swelling of knee following injury	(1) Simple traumatic effusion and/or hemarthrosis	195
Ability to walk	(2) Tear or strain of collateral ligaments	196
	(3) Tear of semilunar cartilage	197
Pain, swelling, and *inability* to stand or bear weight following injury	(1) Fractures of patella	200
	(2) Dislocation of patella	201
	(3) Chronic recurrent dislocation of patella	202
	(4) Rupture of quadriceps tendon	202
	(5) Laceration of quadriceps tendon	203
	(6) Fractures of femoral condyle or tibial plateau	203

A patient with a knee which has been injured complains in general of pain and swelling of the injured part. Sometimes, in addition to pain and swelling, he complains of the inability to stand or to walk after the injury. The diagnostic possibilities are in some measure dependent upon whether the patient complains of pain and swelling following injury, but is able to walk, or whether he complains of pain, swelling, and the inability to walk following the injury. Usually, when the patient is able to walk but complains of pain and swelling of the knee after an injury, the most likely diagnoses are traumatic effusion and/or hemarthrosis of the knee, a tear of the semilunar cartilage, or a tear or sprain of the collateral ligaments. When the complaint is of pain, swelling, and *inability* to stand or walk following injury, the most likely diagnoses are a fracture of the patella, a dislocation of the patella, a rupture of the quadriceps extensor apparatus of the knee, or a fracture of the knee, such as a depressed fracture of the plateau of the tibia, a fracture of the condyle of the femur, or a supracondylar fracture of the femur.

Simple Traumatic Effusion and/or Hemarthrosis

One of the most common injuries to the knee is a simple traumatic effusion. The patient is ordinarily a young, active person who injures a knee while partici-

pating in a sport or twists it while performing some strenuous activity. During the twenty-four hours following the injury, the knee becomes swollen and stiff, aches, and is painful, but the patient is able to walk. Examination reveals a swollen knee, and the swelling outlines the suprapatellar bursa. The depressions normally seen on either side of the patella are absent, and, instead, these areas bulge outward. The patella is ballotable and floating; that is, pressure applied anteriorly over the patella causes it to pass backward toward the femur, and, as the pressure is released, the patella surges forward anteriorly again. Motion, both active and passive, is limited by the pain and tenseness of the effusion. General and poorly localized tenderness is found almost everywhere over the knee. Examination reveals nothing further.

Treatment depends on the severity of the injury, the length of time since the injury, and the tenseness of the effusion. If the patient is treated within twenty-four to forty-eight hours after injury, an ice pack and bed rest will minimize the effusion. If he is treated much later than forty-eight hours after injury a hot pack and bed rest will aid rapid absorption of the effusion. If the fluid within the joint is under great tension, it should be aspirated. The knee joint ordinarily contains 120 to 130 c.c. of fluid when the effusion is under great tension. The fluid, whether it is sanguineous or serous, should be aspirated, and 2 c.c. of Hydrocortone should be instilled in the joint. The Hydrocortone acts as an aid in the prevention of a too rapid reaccumulation of fluid. Following the aspiration, the knee is immobilized with sheet wadding and an Ace Bandage.

Allied to effusion is traumatic hemarthrosis. The injury is usually obtained in the same manner, except that it is more severe, and the fluid in the joint is bloody instead of serous. The distinguishing feature between traumatic effusion and hemarthrosis is that the swelling in hemarthrosis occurs within a few hours of injury instead of within twenty-four to forty-eight hours. Whether the diagnosis is traumatic effusion or traumatic hemarthrosis, the treatment is very much the same. The joint is immobilized with sheet wadding and an Ace Bandage, ice packs are used if the knee is treated within twenty-four to forty-eight hours of injury, and the patient is put at bed rest for two to three days. In addition, if the effusion is too tense, it is aspirated, and 2 c.c. of Hydrocortone is instilled in the knee joint. If the knee is not treated until forty-eight hours after injury, hot packs, bed rest, immobilization, and aspiration are used. The danger in allowing a tense, serous or sanguineous effusion to persist without aspiration is that the ligaments around the joint become stretched and lax, tending to produce a certain amount of instability of the joint later. Another danger in not treating such an injury adequately is that chronic synovitis may result.

Tear or Strain of the Collateral Ligaments

In a tear or strain of the collateral ligaments, the patient complains of pain and swelling of the knee but is able to walk. He is likely to localize the pain in either *the medial or the lateral aspect. The mechanism of the injury consists* of a sudden force, either abduction or adduction, to the lower leg which places stress on the medial or lateral collateral ligament. Examination reveals an

effusion of the knee exactly like that in a simple traumatic effusion. The difference, however, is found when palpation is carried out over either the medial or the lateral collateral ligament, depending on which is injured. Tenderness is found commonly at the origin or insertion of the ligament or, at times, within the body of the ligament itself. Repetition of the original stress, with the knee extended, causes severe pain, while reversal of the original traumatic stress does not. At times it is possible to demonstrate an increase in side-to-side mobility over normal movement. Therefore, the distinguishing features between simple traumatic effusion and strain or tear of the collateral ligament are tenderness overlying the origin or insertion of the collateral ligament and upon repetition of the original stress (either abduction or adduction), pain is elicited.

In general, the objectives of conservative treatment are to relieve the tension in an effusion by aspiration and the instillation of Hydrocortone, to immobilize the joint by applying a plaster cylinder or a supportive bandage (depending upon the severity of the injury), and to protect the joint from its normal function of weight-bearing either by bed rest or by the use of crutches. The plaster cast should remain on until the ligament has healed, which requires two to three weeks. After the cast is removed, physical therapy is instituted if required. Physical therapy should consist of gradually increased active exercises for the knee in which the exercise is graduated through increasingly heavy weights.

The radical treatment of a strain or tear of the collateral ligament consists of surgical repair. At times, the mobility in the knee in a side-to-side plane is so marked following an injury that it is certain there is a rupture, essentially through the main body of the collateral ligament. Under such circumstances, some authorities expose the collateral ligament surgically, repair it, and apply a cast for a period of two to four weeks.

Tear of a Semilunar Cartilage

Although the patient may complain of pain and swelling of the knee following injury, there are certain accessory findings revealed by the history and the physical examination which aid in the differential diagnosis of a tear of a semilunar cartilage. The history is rather clear cut, indicating that the knee was extended suddenly after being in a flexed position and, while extended, that the body was rotated with the lower leg fixed. The patient complains of pain usually in the anteromedial aspect of the knee joint and of inability to extend the knee completely. However, he is able to walk. If the injury has occurred some time in the past, there may be an interval history of the knee joint locking repeatedly to prevent complete extension of the knee or of the knee collapsing repeatedly, suddenly and without warning. These complaints, considered as a group, are extremely suggestive of a tear of the medial semilunar cartilage.

Examination reveals that the knee is partially flexed, that an effusion is present if many hours have elapsed since the injury occurred, that there is tenderness to palpation over the medial joint line anteriorly, and that passive motion into extension is blocked by a soft object.

The injury is sustained as a result of a very specific combination of mechanical events. Either while participating in a sport or engaging in a work activity the patient flexes the knee, causing the medial semilunar cartilage to sink backward more deeply into the joint. Then suddenly, the knee is extended, and, because of the close attachment of the medial cartilage and the collateral ligament, the meniscus does not pass anteriorly with sufficient rapidity. Therefore, it is in danger of being crushed by the medial femoral condyle. Add the natural rotation of the femur on the tibia to these two mechanical movements, and the cartilage is indeed caught and crushed between the tibial and femoral condyles. These factors explain why the medial rather than the lateral meniscus is more commonly injured and why the anterior rather than the posterior horn is crushed. The lateral meniscus, being more loosely attached, more readily moves out of the way of the femoral condyle.

An example of the usual history of such an injury is as follows. Let us assume that the *right* knee is the one concerned. A workman in a squatting position is shoveling material which he will throw over his *right* shoulder. He loads his shovel and starts to rise from the squatting position (extension of the femur upon the tibia after the flexed position has caused the cartilage to sink back into the joint). As he rises, he throws the shovel of material to the *right* and rotates his body to that side (thus giving an external twist to the *right* femur as extension of the knee is carried out). Note in addition that the foot is held in a fixed position as the knee is extended from the flexed position. That is, the femur rotates externally in relation to the tibia because the foot is a fixed point. The anterior horn of the medial semilunar cartilage is crushed between the condyle of the femur and the tibial plateau. The patient suffers immediate severe pain in the knee and is unable to fully extend the leg upon the thigh, either actively or passively. The inability to extend the knee is due to pain and to a soft block of the range of motion, caused by the interposition of the now distorted and crushed meniscus; that is, the joint is locked in flexion.

Careful judgment must be exercised in selecting the proper treatment. The following facts are of aid to the practitioner in reaching a decision. Cartilage heals poorly, so that even if a tear or dislocation is adequately reduced and immobilized for a sufficiently long time, it might not heal. If it does not, the patient will have recurrent episodes of pain, the knee joint will lock repeatedly, or the knee will collapse suddenly. The knee will be unstable and undependable. This condition by itself can be of great danger to a man working in a hazardous occupation where loss of footing may well mean loss of life. Even crossing a street in busy traffic is dangerous if a person has an unstable knee.

However, an appreciable number of menisci apparently heal when treated conservatively and give no further trouble If the present episode is the first, the tear or dislocation is reduced in the following way. The patient is anesthetized, the knee is gently flexed and extended a few times, an *adduction* force is applied to the lower femur, and an *abduction* force is applied to the lower leg. This opens up the medial joint space as wide as possible, and, while it is open, the knee is brought into sudden extension. Often, a click can be heard as the knee is extended. When the operator is satisfied that the cartilage is in the proper position (complete passive extension of the knee without the exertion

of force), then a plaster cast is applied and is allowed to remain for six weeks. Such conservative therapy is successful in a good number of "first-offender" cases.

If the patient is experiencing recurrent trouble, the meniscus should be removed. There are several ways in which recurrent episodes may be manifest. The knee may collapse suddenly and without warning. The patient may be in a kneeling position for a short time and then be unable to rise and extend the knee completely; that is, there are recurrent episodes in which the joint locks. At times, the patient may complain of intermittent attacks of pain and swelling of the knee. In such patients the Jones operative procedure can be used. A small incision is made anteriorly about one inch medial to the mid-point of the patella, extending downward parallel to the patella until the joint line is reached. Hereupon the incision is curved posteriorly for a short distance, with the convexity forward, and thus the medial collateral ligament is out of danger. The capsule of the joint is divided, as is the synovium. The medial meniscus is inspected for tears. Excision of the anterior horn, starting at its attachment to the tibial spine and continuing around the periphery as far posteriorly as possible, follows. It should be noted that the entire meniscus usually cannot be removed through this incision unless a special instrument is used. If the entire meniscus is to be removed, two incisions, one into the anterior and one into the posterior compartment, can be used. Otherwise, a combination approach as described by Cave is used. The Cave incision starts posteriorly and continues downward and forward, with an anterior concavity. The joint is opened by incising the capsule just behind and just in front of the medial collateral ligament. It is advisable to avoid incision of the medial collateral ligament because laxity of this ligament leads to joint instability. After removal of the meniscus, a new fibrous ring appears in due course to take over the function of the original meniscus. Postoperatively, exercises to strengthen the quadriceps should be begun as soon as healing has occurred. The importance of the early institution of these exercises cannot be overemphasized. A very severe injury to, or operation upon, the knee causes the quadriceps muscle to undergo a rapid and profound atrophy. So great is this phenomenon that a whole entity of quadriceps insufficiency can occur. As soon as the wound is well healed (eighth to tenth postoperative day), physiotherapy, directed especially to the quadriceps and gastrocnemius muscles, should be started. Weight-bearing on crutches is allowed from one to three weeks postoperatively, and then the crutches are gradually discarded About two months are needed for full recovery, although the patient is not completely disabled for more than two weeks on the average.

On the whole, the results from the removal of the semilunar cartilage are good The disadvantages of leaving a damaged meniscus in situ are a weak, unstable knee which may give way at a most inopportune time, with possible loss of life, recurrent disabling episodes, and continuous damage to articular surfaces, with early development of post-traumatic arthritis. The complications of excision are postoperative suppurative arthritis or wound infection, neither of which is any more common here than after ordinary surgical procedures, and failure to relieve symptoms. The diagnosis of internal derangement due to a

damaged meniscus is often exceedingly difficult to make, and therefore mistakes are made. Failure to relieve a patient whose disability was not in fact due to a deranged cartilage is to be expected.

Fractures of the Patella

In fractures of the patella the patient complains of pain, swelling, and inability to stand or bear weight following injury. Since fractures of the patella are quite comparable with those of the olecranon, it might be advantageous to review the discussion of Fractures of the Olecranon (p. 329). Both fractures tend to heal with fibrous instead of bony union, and therefore close approximation of the fragments with wires is often performed. Both fractures involve joints, and therefore good reduction is needed in order to avoid later arthritic



Fig 112 —Fracture of the patella without displacement.

changes. Both fractures may have the fragments widely displaced because of muscle pull

Fractures of the patella are sustained as a result of a fall upon the knee when in a flexed position or, occasionally, as a result of sudden muscle pull. Examination reveals a large swelling, and frequently ecchymosis anterior to the patella is present. Active extension of the leg on the thigh is performed weakly if indeed at all. X-ray pictures will, of course, confirm the diagnosis.

For purposes of treatment these fractures may be divided roughly into three categories.

The first type is a fracture with one very large fragment and one small fragment. Ordinarily there is no displacement. (Fig 112.) Treatment consists of the application of a cast, with the knee in extension to relax the pull of the quadriceps tendon as much as possible.

The second type has two or three main fragments which are commonly widely separated. Union by fibrous tissue rather than by bone is likely. Therefore, open reduction is performed. An incision is made just medial or lateral to the patella. Holes are drilled through the fragments, and wire is threaded through these holes in a quadrangular pattern. The wires are tightened to bring the fragments into anatomic reposition. (Fig. 113, *A* and *B*.) A cast is then applied, with the knee in extension.

The third type is the very badly comminuted fracture. There are two possible ways to treat this fracture. Frequently, all of the fragments will fall together nicely if a purse-string suture of heavy silk is placed around them and drawn taut. If this is not effective, then excision of the patella is performed.

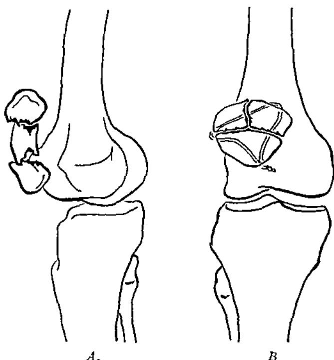


Fig 113—*A*, Fracture of the patella with wide displacement of fragments. *B*, Open reduction and wiring of the displaced fracture of the patella.

In all of the operative procedures just described, the lacerations of the lateral aponeurotic expansions (which frequently accompany fractures of the patella) are carefully repaired Immobilization is carried out for four to six weeks before physical therapy is begun. Weight-bearing is not allowed fully until around the eighth week.

In filling out an insurance form the practitioner should estimate that the patient will be totally disabled for twelve to fourteen weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he may note that nonunion is common.

Dislocation of the Patella

If the patient complains of inability to stand following an injury to the knee, and if the knee is painful and swollen, a moment's observation of the

position of the patella will indicate the presence of a lateral dislocation. X-ray pictures will, of course, confirm the diagnosis. Reduction is ordinarily very simple. The patient is anesthetized. The leg is hyperextended at the knee to relax the pull of the quadriceps muscle, and the patella is grasped firmly and simply moved medially. It ordinarily falls rapidly in place, and a plaster cylinder is applied. Two to three weeks are adequate to allow healing of the tear in the soft tissue. Limited weight-bearing is permitted during this time.

Chronic Recurrent Dislocation of the Patella

Due to a bony deformity, such as genu valgum, or to laxity of the medial expansion of the quadriceps extensor mechanism of the knee (congenital or traumatic), dislocation of the patella may be habitual and recurrent. This dislocation is commonly on the lateral side. The complaints include pain, swelling, and inability to stand or bear weight. The condition should be treated, since neglect may allow a disabling traumatic arthritis to develop within the knee. The condition occurs more commonly in women than in men, and it is believed that underdevelopment of the lateral femoral condyle may be the causative factor. That is, in some persons the condyle is not large enough to prevent the patella from slipping laterally.

Numerous procedures are possible in the treatment of recurrent dislocation of the patella. Many direct their treatment to the soft tissues; that is, the medial aspect of the joint capsule is plicated in order to position the patella medially enough to prevent it from dislocating laterally. In other operations the fascial bands are transferred and implanted to achieve the same mechanical ends. The Hauser operation, on the other hand, is directed not only to soft tissues, but also to the bone. In this procedure the lateral joint capsule is incised, and the patella, the patellar ligament, and its bony attachment on the tibia are freed and moved medially. The patellar tendon is then implanted farther downward and medially upon the tiba. Hence, the patella is constantly pulled downward and medially, which counteracts its tendency to dislocate.

Rupture of the Quadriceps Tendon

The normal tendon is apparently too strong to rupture. Degenerative changes due to use, fraying, repeated trauma, failing vascular supply, etc., will cause a tendon to become weakened to such a degree that rupture is possible. Rupture of the quadriceps tendon is an entity and occurs in elerly men. The following incident is typical of the history of the injury. An elderly man, while going down a stairway, catches the heel of his shoe on a step. He falls with his leg flexed sharply at the knee and at the same time he vigorously attempts to extend his knee in order to maintain his balance. Thus, he exerts a violent extensor muscular effort while the knee is forcibly flexed by the weight of his body. These forces are too great for a degenerated tendon to withstand, and rupture ensues. There is immediate pain in the affected knee. Many times the leg cannot be actively extended upon the thigh (complete rupture of the tendon), or if extension is possible, it is weak (partial rupture). Occasionally, the patient

is able to stand up and walk, after a fashion. However, if he can walk, he exerts an abnormal stress on the opposite (supposedly normal) leg and may rupture the quadriceps tendon on that side.

Examination reveals an effusion in the knee (hemarthrosis), and a characteristic depression is palpable above the patella. In this depression it is possible to feel the femoral condyle with startling ease. There is either marked weakness in the extensor mechanism or total inability to actively extend the leg on the thigh.

Formerly, rupture of the quadriceps tendon was treated conservatively; that is, a cast was applied, with the knee in extension. The results of such treatment are very poor when compared with the results of operative methods. Therefore, operative repair is carried out if it is at all feasible. The torn tendon ends are exposed, the synovium is repaired, the lateral expansions from the quadriceps tendon are sutured, and the tendon is repaired by the most suitable method. Heavy silk may be used or a free graft of the fascia lata may be used as suture material and threaded through the drill holes in the patella. A cast is applied, with the knee in extension, for six to eight weeks, and then physiotherapy is begun. About five months are required to recover good function.

Laceration of the Quadriceps Tendon

Laceration of the quadriceps tendon is sometimes overlooked, and the incorrect diagnosis of laceration of the knee is made instead. If a laceration of the leg involves an area near the patella (perhaps somewhat superior to the patella), the practitioner should strongly consider that the extensor apparatus of the knee has been severed and that the laceration is, in fact, a compound wound of the knee joint instead of a simple and rather benign laceration of the leg. The leg should be tested for muscle power in the same way it is tested in rupture of the quadriceps tendon. That is, the patient is asked to extend the lower leg against gravity and then against resistance offered by the examiner. If this motion is impossible or is but weakly carried out, then the wound should be explored for a laceration of the quadriceps tendon. If this condition is present, the edges of the tendon are refreshed, brought together, and sutured with heavy silk. A cast is applied to the leg, with the knee in extension, for six to eight weeks, and then physical therapy is instituted.

Fractures of the Femoral Condyles or the Tibial Plateau

Supracondylar Fracture of the Femur.—A supracondylar fracture of the femur is not especially common. The presenting complaints are pain, swelling, and the inability to stand or bear weight following an injury. The fracture line may be either transverse or oblique. However, the roentgenograms usually reveal that the distal fragment is displaced posteriorly, that the shaft of the femur is directed anteriorly into either the quadriceps muscle bellies or the quadriceps tendon, and that the distal fragment is tilted posteriorly toward the popliteal fossa. (Fig. 114.) The angulation toward the popliteal fossa is due to the pull of the heads of the gastrocnemius muscles on the distal fragment. This mecha-

nism contributes to the success of a reduction, since flexion of the knee relaxes the pull of the gastrocnemius and affords a better chance of apposition of the distal fragment with the shaft.

Treatment consists of either skeletal traction or manipulation and the application of a cast. If manipulation is attempted, the knee should be flexed and then immobilized in the cast in the flexed position.

In filling out an insurance form the practitioner should estimate that the patient will be totally disabled for sixteen to eighteen weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he may note loss in the normal range of motion may occur.

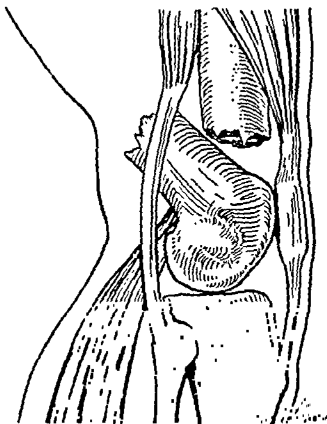


Fig. 114 —Supracondylar fracture of the femur (-transverse) Note the pull exerted by the gastrocnemius (From Larson, C B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C V. Mosby Co)

Intercondylar Fracture of the Femur ("T" Fracture).—The presenting complaints in a "T" fracture include pain, swelling, and inability to stand or bear weight. Management of such a fracture (transverse fracture just above the condyle and a joining vertical fracture splitting each condyle from the other), includes a good restoration of anatomic contour to prevent joint incongruity. If satisfactory position cannot be obtained through the use of traction and external pressure from the side upon the condyles, open reduction is indicated.

In filling out an insurance form the practitioner should estimate that the patient will be totally disabled for sixteen to eighteen weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he may note that loss of the normal range of motion may occur.

Fracture of the Tibial Plateau.—A depressed fracture of the tibial plateau is a serious injury, although not too common. The patient complains of pain, swelling, and inability to stand or bear weight. The tibial plateau is the flaring portion of the proximal tibia which enters the knee joint. It is fashioned into two shallow concavities which receive the femoral condyles. The fracture line runs vertically from the articular surface of the tibia downward and outward, so that essentially the flaring portion of the tibia is split from the remainder of the bone.

The mechanism producing the fracture is as follows. The patient falls in such a way that the lower leg is forcibly abducted or adducted on the thigh. The femoral condyle swings downward, impinges on the tibia, and depresses the plateau downward and medially or laterally (depending upon whether the medial or the lateral tibial condyle is involved). If, for example, the leg is forcibly abducted at the knee and the femoral condyle causes a depressed fracture of the lateral tibial plateau, the *medial* collateral ligament is likely to be torn, and the *external* semilunar cartilage is likely to be crushed. If the leg is forced into adduction at the knee, the reverse occurs. That is, the medial tibial plateau is depressed, the *medial* semilunar cartilage is crushed, and the *lateral* collateral ligament is torn.

An accompanying hemarthrosis is almost inevitable. Therefore, it is good practice to aspirate the knee, under strict aseptic conditions, before reduction is performed Reduction can often be accomplished by exerting external pressure on the tibial condyle, directed upward and toward the midline. Some orthopedists recommend an operative procedure whereby the semilunar cartilage is removed, the joint is cleared of the fragments of articular cartilage which frequently are present, the shape of the articular surface is reconstituted, and the tears in the collateral ligaments are repaired. The displaced fragment sometimes is held in position by a screw bolt which passes through and through both tibial condyles. If manipulative reduction fails and the extensive operative procedure just described is undesirable, traction is an acceptable method of treatment. Immobilization should be carried out for eight weeks.

The common complication is, of course, that the fracture heals in a deformity, with one half of the tibial plateau depressed. If the lateral half is affected, a valgus deformity should be expected. If the medial half is affected, a varus deformity results. These deformities lead in time to a painful hypertrophic arthritis. In addition to a genu valgus or genu varum deformity, another complication is lateral instability of the knee. That is, with the knee extended, the tibia can be moved too freely from side to side. Such instability is caused by the rupture of the collateral ligaments of the knee, which occurred at the time of the fracture.

In filling out an insurance form the practitioner should estimate that the patient will be totally disabled for eighteen to twenty weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he may

note that loss of the normal range of motion, lateral instability, and either a valgus or varus deformity may occur.

NONTRAUMATIC DISORDERS OF THE KNEE

Complaint	Likely Diagnoses	Page
Pain and swelling of knee without injury	(1) Osteochondritis dissecans	206
	(2) Osteochondromatosis	207
	(3) Bursitis	208
	(4) Tenosynovitis	208
	(5) Baker's cyst	209
	(6) Discoid meniscus and cyst formations on lateral meniscus	209
	(7) Hypertrophic arthritis	210
	(8) Rheumatoid arthritis	211
	(9) Villous synovitis	212
	(10) Tuberculous arthritis	213

Many disturbances of the knee, accompanied by pain and swelling, arise more or less spontaneously and are not associated with any particular injury. These include various types of arthritis, loose bodies within an articulation, and irritative conditions, such as bursitis or tenosynovitis.

Osteochondritis Dissecans

If a patient complains of recurrent episodes of pain and swelling in the knee and there is no history of an injury, the condition may be caused by a loose body, a joint mouse, or a chondro-osseous body within the knee due to osteochondritis dissecans. The history consists of recurrent episodes of pain and swelling in the knee, associated with episodes in which the knee collapses or seems to collapse. The collapsing is not the same type which occurs in a tear of the semilunar cartilage of the knee. Rather, the knee seems to be on the verge of giving away. In addition, the patient may describe episodes in which the knee seems about to lock, but never quite does. Furthermore, he may complain that he feels a lump moving around within the knee when he palpates it.

A loose body, a chondro-osseous body, or a joint mouse (as it is sometimes called) within the knee is caused by several different processes. A loose body is classified as an internal derangement of the knee as well as a tear in the meniscus. Three common conditions which produce a loose body are osteochondritis dissecans, osteochondromatosis, and a fractured osteophyte (the breaking off of a hypertrophic bony spur).

Osteochondritis dissecans is a dissecting inflammatory process involving the bone and cartilage. This disease is prone to occur in the young adult. In addition to the knee, it can affect the hip, the shoulder, the ankle, and the elbow. On the medial aspect of the lateral femoral condyle, a piece of articular cartilage and underlying bone about 5 to 8 mm. in size becomes demarcated from the surrounding tissue through some process, perhaps avascular necrosis. This small button of articular cartilage and bone which is undergoing necrosis appears dense on the roentgenogram. It is gradually raised up and sloughed (or dis-

sected) free. (Fig. 115.) At this point it becomes a loose chondro-osseous body, causing recurrent locking of the knee, pain, and effusion. Diagnosis is made from the roentgenograms. Treatment consists of surgical removal of the loose body and smoothing of the bed from which it originated. The etiology is in dispute; it has not yet been established whether the condition is due to avascular necrosis or to trauma.



Fig. 115.—Osteochondritis dissecans of the knee. Note oval-shaped fragment of bone on the surface of the femoral condyle.

Osteochondromatosis

Another condition in which the patient complains of recurrent episodes of pain and swelling of the knee without injury is osteochondromatosis, a disease process which affects the synovium of the knee and believed to occur in the following manner. Large hypertrophic villous tips form in several locations on the synovium. It is assumed that the ends of the villous tips then undergo degeneration and that following the degeneration, metaplasia into an attached chondro-osseous body takes place One (or more) of these bodies may break off and wander through the joint—the so-called joint mouse or loose body. Characteristically, large numbers of bodies are formed. (Fig. 116.) Therefore, upon opening the joint one may find several attached chondro-osseous bodies on the synovium and several free in the joint. They can be responsible for severe, recurrent internal derangement. The diagnosis is made from a history of recurrent locking of the joint, which is not characteristic of a meniscal lesion, by palpation of one or more of the loose bodies at various places in the joint, and by the roentgenograms It is noteworthy that the patient not uncommonly discovers one of these bodies when he palpates the knee. Osteochondromatosis usually occurs in the older age group. Arthrotomy, with removal of the loose bodies, or possibly synovectomy, is the treatment of choice. Naturally, if numerous chondro-osseous bodies are found attached to the synovium, a synovectomy is performed. If only a few attached bodies are present, local excision of these bodies, instead of a synovectomy, is performed.



Fig. 116 —Osteochondromatosis of the knee.

Bursitis

Complaints of pain and swelling of the knee without history of injury may be associated with bursitis. There are many bursae around the knee joint. Some are inconstant and adventitious (that is, they appear upon specific irritation), while others are constant. These bursae may at times communicate with the knee joint Those most commonly encountered are the prepatellar, the biceps, and the semimembranosus bursae. An inflammatory process, due to mechanical irritation, may occur in any of these, or a pyogenic infection may localize in any of them.

The so-called housemaid's knee is an example of irritative prepatellar bursitis Due to constant kneeling, a person engaged in housework may develop a red, swollen, hot, and tense prepatellar bursa. The fluid in this bursa is sterile. Aspiration of the fluid and the injection of Novocain and Hydrocortone give prompt relief The affected knee should be immobilized and protected from ordinary function for a few days If chronic bursitis occurs, excision of the sac is the procedure of choice Sometimes hemolytic streptococcus or hemolytic staphylococcus infects the prepatellar bursa. In these circumstances surgical drainage is performed, and systemic chemotherapy is instituted. An elevation in the temperature occurs in patients with pyogenic bursitis but not in those with irritative bursitis as a rule

Both the biceps bursa and the semimembranosus bursa are subject to the same type of irritative inflammatory process as the prepatellar bursa The diagnosis is made on the finding of localized tenderness over these bursae, laterally in the biceps bursa and medially in the semimembranosus bursa. Treatment consists of aspiration of the fluid and infiltration with Novocain and Hydrocortone.

Tenosynovitis

Sometimes pain and swelling of the knee is actually associated with tenosynovitis of either the medial or lateral hamstring tendons around the knee.

Examination will reveal certain conditions which indicate the presence of tenosynovitis of the medial or lateral hamstring tendons. There is tenderness overlying the course of either the medial or the lateral hamstring tendons, posteromedially or posterolaterally, as the case may be. Furthermore, if the knee is flexed at a right angle and held in that position while the examiner attempts to extend the knee with moderate force, the patient will experience pain. If the tenosynovitis is associated with a bursitis, situated either medially or laterally, then the injection of Novocain and Hydrocortone into the bursa may cause the symptoms to subside promptly. However, if the tenosynovitis is primary and occurs alone, the knee should be immobilized in a plaster cylinder for approximately three weeks to provide sufficient rest so that the inflammatory process can subside. Occasionally, in association with tenosynovitis there may be a cyst in the form of a ganglion whose stalk arises from or in association with the hamstring tendons.

Baker's Cyst

A patient complains sometimes simply of swelling in back of the knee, without pain or any other disability. On the other hand, sometimes a cyst behind the knee is accompanied by pain and swelling of the knee as a whole. This swelling, which occurs in the popliteal fossa, is called Baker's cyst. It is lined with synovium and connected with the knee joint through the posterior capsule. Some orthopedists consider Baker's cyst to be a ganglion, some believe it is a herniation of the joint, and still others think that it is a bursa. At any rate, the swelling is palpable in the popliteal fossa and may cause local pain to radiate from the knee down into the lateral aspect of the calf and leg. It must be distinguished from an aneurysm of the popliteal artery, an arteriovenous aneurysm, an enlarged lymph node, and a lipoma. Excision of the cyst, together with careful ligation of the stalk, yields good results. Excision is performed if pain is present, if there is no pain, the patient should be reassured of the benign nature of the swelling.

Discoid Meniscus and Cyst Formations on the Lateral Meniscus

It is more common for the medial meniscus to be torn than for the lateral meniscus. However, the lateral meniscus is subject to the formation of a cyst which occurs on the anterolateral aspect of the knee. Intermittent attacks of pain and the presence of a palpable object which increases in size cause a patient to seek the advice of a physician. The diagnosis is readily arrived at through inspection and palpation of an anterolateral cystic tumor at the joint line which seems to be attached to the lateral semilunar cartilage. Excision of the anterior horn of the cartilage and of the tumor is the treatment of choice. Pathologically, the tumor is a multilocular cyst containing glairy myxomatous material. It is connected by a stalk to the meniscus, and frequently it occurs in association with a discoid meniscus.

A meniscus of the knee may develop improperly, resulting commonly in discoid formation of the meniscus. Frequently, there are no symptoms or disabilities associated with this condition. The complaint usually is that the knee continually "clicks" as the patient walks. Some orthopedists believe that

such a discoid formation may degenerate into a cyst. If the condition causes a disability, the meniscus is removed. In the absence of disability, the patient should be given the explanation of the cause of the "clicking"and be reassured that it is not harmful.

Hypertrophic Arthritis

The patient may complain of recurrent episodes of pain and swelling of the knee not caused by undue trauma. X-ray pictures are one means of determining that the difficulty is due to hypertrophic arthritis. (Fig. 117.) Examination reveals effusion, and crepitus and grating are likely to be palpated when the knee is moved. Tenderness is generalized and rather poorly localized in

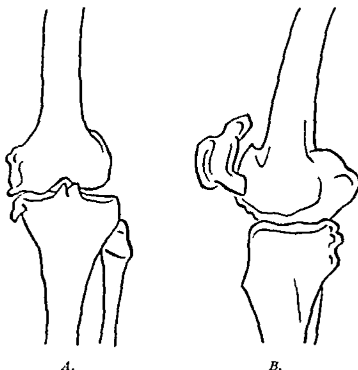


Fig. 117 — *A.* Anteroposterior view and *B,* lateral view of hypertrophic arthritis of the knee. Note the irregularity of the joint surfaces and the formation of spurs.

contradistinction to other conditions, such as cyst formations, bursitis, and tenosynovitis, especially if the patient is in the age group in which hypertrophic changes are anticipated (over 55 years of age). Further examination may reveal that the distal interphalangeal joints of the fingers are swollen and deformed and are typical of hypertrophic arthritis Passive motion of the joint may be limited by pain, by the tenseness of the effusion, or by the irregularity of the joint surface itself.

There are several conservative methods of treatment. A plaster cylinder may be applied to the afflicted part for three to four weeks. The effusion may be aspirated and hydrocortisone instilled in the joint, with or without the application of a plaster cylinder. Some prefer to treat the condition by diathermy

and the application of a mildly supportive bandage of sheet wadding and an Ace Bandage. If conservative measures fail and if the condition is sufficiently disabling, operative measures are possible.

Operative measures consist of a synovectomy, to remove an inflamed membrane, and a cheilectomy, to remove a bony spur. These procedures are usually done in association with curettage of the irregular areas of degeneration in the articular cartilage. Another general operative procedure, if the condition seems severe enough to warrant it, is an arthroplasty (described under Rheumatoid Arthritis).

Rheumatoid Arthritis

In rheumatoid arthritis it is common for either one or both knees to be involved. The patient complains of recurrent episodes of pain and swelling in either one or both knees. Questioning will reveal that, in the past, the patient has had episodes of pain and swelling in other parts of the body, particularly in the proximal interphalangeal joints of the fingers or in the metacarpophalangeal joints of the hand. The presence of rheumatoid arthritis may be suspected, particularly if the patient is a young woman. The roentgenograms may be negative, or they may show findings compatible with rheumatoid arthritis, such as osteoporosis of the bones which enter the knee, narrowing of the joint space, or cystic areas within the bones close to the joint line. Clinical examination may reveal swelling and effusion of the joint, thickening of the synovium, limitation of motion due to pain or effusion, and generalized tenderness of the joint, but no sharply localized areas of tenderness. Conservative treatment of the condition includes general management of the arthritic process, and of the patient as a whole, by the administration of either ACTH or cortisone, if warranted clinically. The patient is advised to obtain more rest and is placed on a high vitamin and high caloric diet unless he is overweight.

Conservative local treatment of the knee joint consists of rest of the joint, using a support during the day and, sometimes, applying posterior molded plaster splints at night. Another conservative measure is bed rest for the patient, with adhesive traction applied to the leg to prevent or to correct a flexion deformity and to rest the joint. It is also possible to aspirate the effusion and to instill Hydrocortone in the joint. If the rheumatoid arthritis has progressed to such a degree that there is severe limitation of motion due to irreversible intra-articular changes, arthroplasty of the knee should be considered. For many years, the orthopedist has been expected to create a properly functioning joint to replace a joint rendered functionless by any of several processes. If the disability is great enough, arthroplasty is performed for a joint which is ankylosed by bone, or whose motion is limited by incongruity of the joint surfaces or by adhesions, whether or not pain is present.

Until recently, arthroplasty consisted of cutting through an area of ankylosis, smoothing of the joint surfaces, and covering the surfaces with fascia lata. The fascia was interposed to prevent the union of the two bones entering the new articulation. Recently, Vitallium has been used in arthroplasty to replace the

fascia In operations on the knee, in particular, nylon is used instead of fascia or Vitallium to cover the raw, bleeding surface of the bone. Several factors should be considered before an arthroplasty is undertaken. First, the patient should probably be between 18 to 50 years of age. Arthroplasty on a patient under 18 years of age might injure an epiphysis, and on a patient over 50 years of age, it many times produces very disappointing results. In a patient over 50 years of age, the disease process is likely to be long standing, the quality of the neighboring bone is not so good as in a younger person, and the musculature is less well preserved. In addition, the older the patient is, the less inclined he is to exert the extra effort necessary in successful rehabilitation. The economic status of the patient should be considered, also, taking into account whether he is the main support of the family and whether he can assume the burden that a long hospitalization entails. The type of work which the patient does is a contributing factor in the decision to perform an arthroplasty. If he works at heavy labor, it is better for him to have a stable, ankylosed, painless joint in good position than a movable, weaker joint. Furthermore, while arthroplasty is performed to correct disabilities produced by several different disease processes, the results in rheumatoid arthritis are poorer in general than in post-traumatic conditions or other causes of joint incongruity. However, in a patient with disability due to rheumatoid arthritis, if two main joints in one extremity, such as the hip and the knee, are ankylosed or if a combination of ankylosis in one main joint in one lower extremity and in one main joint in the other extremity produces a grave disability, arthroplasty should be performed if at all possible.

To summarize, in the treatment of disabilities of the knee due to rheumatoid arthritis, conservative treatment consists of rest for the joint using either a plaster cylinder and/or night splints, aspiration of the effusion and intra-articular injection of Hydrocortone, or adhesive traction with the patient at bed rest, together with general systemic treatment with cortisone and ACTH. If the disability is grave enough and if the damage to the knee is sufficiently severe, the operative procedure of arthroplasty is performed.

Villous Synovitis

Clinically, recurrent attacks of pain and effusion in the knee may cause a patient to seek relief. Examination reveals an effusion of the knee. Passive motion of the knee is limited because of the tenseness of the effusion. Palpation in the suprapatellar area shows that the synovium is thickened and has a boggy consistency. X-ray pictures which are negative or which reveal but little hypertrophic change will distinguish this condition from osteochondritis dissecans and osteochondromatosis. Furthermore, the condition can be distinguished from bursitis and tenosynovitis because it lacks the specifically localized areas of tenderness that these conditions show. It can be distinguished from Baker's cyst by the absence of specific swelling in the popliteal fossa and from rheumatoid arthritis by the absence of recurrent pain and swelling in the other joints, particularly the proximal interphalangeal joints of the hand. Pathologically, the synovium of the knee is thickened, hypertrophied, and pleated in villous

folds. Microscopic examination reveals the synovium to be infiltrated with lymphocytes and polymorphonuclear leukocytes. The blood vessels are increased in number and size; that is, the synovium presents a pathologic picture of acute and chronic inflammatory change. Villous synovitis may be associated with hypertrophic arthritis involving the knee, but sometimes very little bone or joint change is present other than that in the synovium.

Conservative treatment consists of adequate rest for the knee joint; that is, a plaster cylinder is applied for a period of three weeks. When the plaster cylinder is removed, the effusion is usually gone, and the synovium has usually returned to a more nearly normal state. Conservative therapy can also include aspiration of the effusion and the instillation of Hydrocortone into the knee joint, after which the application of a cast is optional. If the process cannot be controlled by conservative measures, synovectomy is the indicated surgical treatment. It is indicated if the disease is sufficiently disabling and if the attacks occur often enough to warrant surgical intervention. Practically, synovectomy is limited to the knee joint, although, theoretically, it is applicable to other joints. A long parapatellar incision is made on the medial aspect of the knee The joint is opened, and the synovium is picked up as a single layer. The synovium is then dissected from the surrounding tissues. This means that it is freed from the posterior aspect of the quadriceps tendon, from the anterior aspect of the femur, and from either side of the patella. The patella is reflected laterally during the procedure. Therefore, it is apparent that only the synovium in the suprapatellar bursa and in the anterolateral and anteromedial compartments is removed. The posterior compartments are untouched. Physiotherapy is begun about ten days after the operation. The results of synovectomy for villous synovitis are good A new synovium forms either by metaplasia or by growth from the synovium left in situ at the time of operation.

Tuberculous Arthritis

Sometimes, a patient with a tuberculous infection of the knee complains of acute pain, swelling, redness, and an elevated temperature. However, it is perhaps more common for the patient to complain of a rather constant and persistent painful, swollen knee. Examination reveals a thick, boggy synovium to palpation, and the swelling of the knee seems to be due more to the thickness of the synovium than to fluid within the knee joint. Motion is usually markedly limited because of both the pain and the synovial swelling. X-ray pictures reveal the destruction of a joint which is typical of tuberculous arthritis.

Management should include the establishment of the diagnosis by finding the primary source of the tuberculosis, which most likely will be pulmonary. As a further test a guinea pig should be inoculated with the aspirate from the knee joint. Conservatively, the patient is placed at bed rest, and a high caloric and high vitamin diet is prescribed. Systemic treatment consisting of the administration of streptomycin and para-aminosalicylic acid is given. The knee is placed in a cast in a position of optimum function, keeping in mind that joint stiffness might result. If the process is not brought under control by these

conservative measures, then surgical intervention is indicated. The surgical procedure of choice is arthrodesis, the purposes of which are to produce a stable and painless joint and to control the infectious process through the prevention of joint motion. Arthrodesis is ordinarily performed by cutting away the articular surfaces of the joint and approximating the raw, bony surfaces until healing takes place, just as in the treatment of a fresh fracture. In addition, a bone graft is sometimes placed across the joint space, in essence effecting an intra-articular arthrodesis. When an arthrodesis is performed, the limb is placed in a position of optimum function, which in the case of the knee amounts to 10 to 15 degrees of flexion.

Chapter Five

*Disturbances of the Hip in the Adult**

ANATOMY

The hip joint is a ball and socket joint. The acetabulum is formed on the lateral wall of the pelvis and is deepened by a rim of cartilage. Spanning the joint between the acetabulum and the femoral head is the ligamentum teres, which is one source of blood supply to the femur. During childhood this source of vascular supply is not of great importance, but during early adulthood much of the blood supply comes from this source. Its importance again diminishes from middle age on. In the adult the femoral head and neck are at an angle of approximately 120 degrees to the shaft of the femur. In childhood this angle is greater and can be as much as 140 degrees. A decrease in this angle so that it approaches 90 degrees produces a coxa vara deformity, and an increase in the angle so that it is greater than 120 degrees produces a valgus deformity. In addition to the 120 degree angle of the neck to the shaft, the neck is anteverted in relation to the shaft. Thus, the head and neck point anteriorly to the shaft by about 20 degrees.

The greater trochanter is a large prominence formed at the superior and lateral aspects of the femoral shaft. It is the site of the attachments for the abductor and extensor muscles (the glutei), for the external rotators (the pyriformis, gemelli, and obturator internus), and for some of the internal rotators (the anterior fibers of the gluteus medius and minimus).

Situated diagonally opposite and below the greater trochanter is the lesser trochanter, to which the iliopsoas (flexor of the hip) is attached. The femoral neck joins the shaft at the region of the trochanters.

The capsule of the hip joint arises from the rim of the acetabulum and inserts on the femoral neck almost as far distally as the trochanters. Thus, almost all of the neck is within the hip joint.

ORTHOPEDIC EXAMINATION OF THE HIP

Orthopedic examination of the hip follows a definite plan. The bony landmarks are of particular value. Thus, the anterosuperior spine of the ilium and

*See also Disturbances of the Hip in Childhood (page 66) in Chapter 1, Disease or Affections in Childhood.

the iliac crest on one side are palpated and compared with the opposite side. Next, the prominences of the greater trochanters are palpated. One trochanter is examined to determine whether it occupies approximately the same position as the one on the opposite side. If one is higher than the other, a disturbance, such as congenital dislocation of the hip, coxa vara deformity, absorption of the femoral neck, etc., may be present. The tip of the greater trochanter is palpated at the center of Nélaton's line (an imaginary line connecting the anterior-superior iliac spine with the ischial tuberosity). This is a convenient way to determine whether the trochanter is higher than normal.

Beneath the aponeurotic portion of the gluteus maximus and overlying the greater trochanter is a bursa which is subject to irritative inflammation. Consequently, tenderness over the greater trochanter is sought during this part of the examination. The effect on the position of the trochanter of an upward thrust on the femur is noted.

The range of motion of the hip is observed. During this procedure motion of the pelvis should be controlled as much as possible. Normally, the patient is able to flex the thigh onto the anterior abdominal wall and grasp the extremity just below the knee (which is also in flexion) with both hands. With the patient in this position, the opposite hip is observed, and, if it is flexed, probably a flexion contracture on that side is present.

Abduction, adduction, internal and external rotation, and posterior extension of the hip are tested. Normally, abduction to about 45 degrees from the midline is possible. Adduction is adequate if the patient is able to cross the legs (about 45 degrees). Internal rotation of about 30 degrees is normal, and normal external rotation is about 60 degrees. Normal extension of the hip posteriorly is 30 degrees.

The following is an excellent method for simultaneously testing internal and external rotation and comparing both sides while the pelvis remains immobile. The patient assumes a prone position and flexes the knees to 90 degrees. Then, with the thighs parallel and touching each other, the lower legs are moved laterally away from each other. This causes the thighs to rotate internally. If limitation of internal rotation is present on one side, the opposite normal lower leg will pass through a greater arc. In testing external rotation this procedure is reversed, and the lower legs are crossed (while still flexed to 90 degrees on the thighs)

After the range of motion has been observed, the patient is instructed to stand and bear weight, first on one leg and then on the other. This may reveal a positive Trendelenburg sign. Normally, when weight is borne on one leg, the gluteus medius on that side contracts, stabilizes the pelvis on the femur, and maintains the pelvis level However, if there is a disturbance of this mechanism, the pelvis cannot be maintained level, and the opposite *normal* side falls. Assume that, due to anterior poliomyelitis, the gluteus medius is weak. When the patient attempts to bear weight on the affected side, the gluteus medius is unable to stabilize the pelvis Thus, the opposite *normal* side of the pelvis drops and the buttock on the *normal* side is observed to fall. Weakness of the gluteus medius is not the only pathologic state which can produce a positive

Trendelenburg sign. A dislocated hip (congenital) gives the same sign, since the pelvis cannot be stabilized on the femur. Nonunion of a fracture of the femoral neck might also produce the same sign for the same fundamental reason. In other words, any condition which interferes with the triangle of muscle and bone formed by the gluteus medius, the neck and head of the femur, and the wing of the ilium can produce a positive Trendelenburg sign.

To complete the examination, the length of the legs and the girth of the thighs are measured.

In summary, orthopedic examination of the hip is carried out systematically. The bony prominences are palpated and departures from the normal are noted. The passive and active range of motion of the hip joint are tested, with the patient prone and then supine, and the ability of the patient to bear weight alternately on each extremity is tested. As the active range of motion is examined, the muscle strength is tested against the resistance of the examiner.

GENERAL DISTURBANCES OF THE HIP

The two groups of disturbances to be discussed here refer mainly to adults. They are divided into complaints due to an acute injury with an immediate inability to walk or bear weight and complaints not due to acute injury accompanied by pain in the hip and a limp, although the ability to walk has been maintained. Among the acute injuries of the hip are fractures of the femoral neck, intertrochantric fractures, and traumatic posterior dislocation.

It is especially true in nontraumatic conditions affecting the hip that the disturbances of childhood involving the hip, modified by years of weight-bearing on incongruous joint surfaces, come to fruition in adulthood, with disabling results Only in the adult can the complete picture of such conditions as Legg-Perthes' disease, slipping capital femoral epiphysis, etc., be discerned. Therefore, common diagnoses in the adult are malum coxae senilis, hypertrophic arthritis, aseptic necrosis, etc.

TRAUMATIC INJURIES OF THE HIP

Complaint	Likely Diagnoses	Page
Pain in hip and inability to stand or walk following injury	(1) Fracture of femoral neck	217
	(2) Intertrochanteric fractures	223
	(3) Traumatic posterior dislocation of hip	225
	(4) Fractures of femoral shaft	227

FRACTURE OF THE FEMORAL NECK

When the presenting complaint is inability to stand or walk, with pain in the hip, following an injury, it may be due to either a fracture or a dislocation of the hip. However, traumatic dislocation of the hip is more likely to occur in a young person who is subjected to severe violence, such as would occur in an automobile accident, and a fracture is more likely to occur in an elderly person who experiences minimal violence, such as a fall within the home.

Frequently, when the term "fractured hip" is used, no attempt is made to distinguish between two very different fractures—a fracture of the neck of the femur or an intertrochanteric fracture of the femur. The capsule of the hip joint inserts almost at the junction of the neck of the femur with the greater and lesser trochanters. Therefore, the neck is *really within the hip joint*, and hence a fracture of the femoral neck is also intracapsular. The term extracapsular applies to an intertrochanteric fracture. These two fractures differ from one another in the following respects: the age group in which each occurs, the ability to heal (the percentage of nonunion), blood supply, the type of deformity occurring in malunion, mortality rate, complications, and treatment.

A fracture of the neck of the femur usually occurs in a person approximately 60 years of age (Fig. 118, *A*) and is sustained by a fall on the hip. The patient is ordinarily unable to arise or bear weight. The affected lower extremity is held in external rotation and is shorter than the unaffected leg. The greater trochanter is palpable in the buttock. The tip of the greater trochanter is above Nélaton's line instead of on it as is normal. (It will be remembered that Nélaton's line is an imaginary line which connects the anterosuperior spine of the ilium with the ischial tuberosity.) The importance of these signs in diagnosis cannot be too strongly emphasized. A 60-year-old person who falls on a hip and presents the clinical signs of external rotation of the leg, shortening of the leg, and the greater trochanter in the buttock in a position above Nélaton's line has a fracture of the femoral neck or intertrochanteric region unless another condition can be proved

The blood supply to this region comes from a large posterior capsular artery which crosses the joint and plunges into the neck of the femur, from nutrient vessels entering the shaft distal to the trochanters, from capsular vessels which enter the bone in the region of the trochanters, and a very small amount from the vessel of the ligamentum teres. Thus, it can be seen that the intertrochanteric region has a much better blood supply than has the neck of the femur. Before the advent of the Smith-Petersen nail, the rate of nonunion of fractures of the femoral neck was high—perhaps 70 per cent. Since it has been in use, the rate of nonunion has fallen to less than 30 per cent. Consequently, the accepted method of treatment of a fracture of the neck of the femur is Smith-Petersen nailing or a similar procedure.

The fracture is reduced by one or the other of two standard procedures, either the Whitman or the Leadbetter maneuver The Whitman maneuver consists of three steps. First, traction is applied to the affected leg to overcome the shortening. Second, the leg is rotated internally while forward pressure (or lifting up) is applied simultaneously to the greater trochanter. Thus, the greater trochanter is lifted forward out of the buttock, the fracture surfaces are opposed, and the original external rotation is overcome. Third, the leg is swung into abduction while the internal rotation is maintained. Abduction tightens the "Y" ligament of Bigelow over the fracture site and stabilizes the reduction. It should be noted that the three steps (traction, internal rotation, and abduction) *must* be performed in that order, or reduction of the fracture cannot be accomplished In the Leadbetter maneuver the thigh is flexed to 90 degrees upon the abdomen, with the knee flexed to 90 degrees. Traction is exerted in

a line with the femur (vertical to the abdomen), and then the femur is rotated internally. Following this, and while maintaining the internal rotation, the thigh and leg are extended and the entire lower extremity then abducted. It will be noted that in both the Leadbetter and the Whitman maneuvers, the essence of the treatment is traction, internal rotation, and abduction.

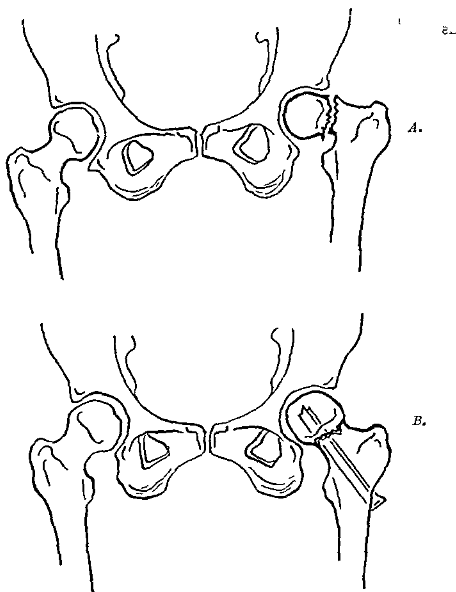


Fig 118.—*A*, Fracture of the neck of the femur. *B*, Fracture reduced and Smith-Petersen nail in place.

Whichever of these methods of manipulative reduction is used, a simple test for reduction, the Leadbetter heel-palm test, can be applied. After it appears that reduction has been obtained, the heel of the affected leg is allowed to rest freely on the operator's palm. If the leg remains in internal rotation or a neutral position, reduction has probably been obtained. If it falls into external rotation, reduction has not been obtained. The Leadbetter heel-palm test is not suitable to apply to a reduction of an intertrochanteric fracture, since

stability in a reduction in a fracture of the femoral neck depends upon a tight ligament of Bigelow. This ligament is not a factor in an intertrochanteric fracture, which occurs outside and distal to the capsule of the hip joint.

After reduction, the leg is maintained in abduction and internal rotation by the use of the footpiece on a special fracture table while the operator inserts a Smith-Petersen pin. Sometimes the operator's assistant holds the hip in reduction. A lateral incision is made overlying the junction of the greater trochanter with the shaft. The fascia lata is divided, and the vastus lateralis muscle is cleared from the shaft. The Smith-Petersen nail is then inserted in the shaft a little below the greater trochanter. The objective is to insert the nail through the center of the neck across the fracture site and into the head. Roughly, the approximate course of the nail is angulation toward the umbilicus. Periodically during insertion of the nail, x-ray pictures in both the anteroposterior and lateral projections are taken. (Fig. 118, *B.*) If the direction of the nail is not satisfactory, it is withdrawn, and the angle is changed. After the nail has been inserted well into the head of the femur, the wound is closed. It *should be noted that this is not an open reduction, since the fracture site is not* exposed; it is called "blind nailing." Furthermore, this operative procedure should not be confused with an entirely different Smith-Petersen operative approach to the hip joint which is used to expose the hip joint anteriorly. Last, it should be noted that no cast is applied.

Some orthopedists now believe that a fracture of the surgical neck of the femur is as an emergency and that the nailing should be done immediately. In immediate Smith-Petersen nailing there is little time for the general systemic condition of the patient to deteriorate, and also the chances for union might be improved.

The patient is kept at bed rest for twelve weeks after a Smith-Petersen nailing operation. At the end of this period, he is put on crutches, with gradually increased weight-bearing on the affected extremity. After sufficient muscle power has been developed, he is graduated to a cane and eventually is allowed to walk without the cane Rehabilitation ordinarily requires three to six months after the patient is ambulatory. The over-all mortality in fractures of the femoral neck is about 10 to 15 per cent. Bronchopneumonia, failure of kidney function, and poor cardiac status are the contributory conditions largely responsible for mortality

Prosthetic reconstruction of the hip is also performed in an acute fracture of the femoral neck In this procedure the hip joint is approached either posteriorly or anterolaterally (Smith-Petersen approach). After the fracture has been exposed, the femoral head is removed A prosthetic device of stainless steel in the shape of the femoral head is applied to the remaining portion of the neck and shaft of the femur. There are several prosthetic appliances; the Judet and the Moore are two that are well known. Prosthetic reconstruction in an acute fracture of the femoral neck is performed only in a very special circumstance. (Fig. 119.) If the fracture is subcapital (that is, if it is located at or very close to the junction of the head with the femoral neck), the chances for nonunion are markedly increased. In addition, even if union occurs, aseptic

necrosis of the femoral head may frequently result. Therefore, rather than risk nonunion or aseptic necrosis (particularly in an aged person who can ill afford a long disabling illness), prosthetic reconstruction may be performed as a primary method of treatment in an acute fracture of the femoral neck. Also, if nonunion in a fracture of the femoral neck occurs, prosthetic reconstruction of the hip can be performed, instead of one of the procedures discussed below.

Nonunion presents many exceedingly complex problems. In general one of the most important considerations in the treatment of nonunion is the condition of the head of the femur. If it has remained viable and if there is only nonunion of the neck, then an intertrochanteric osteotomy is a satisfactory



Fig. 119 —Prosthesis replacing the femoral head.

solution (Fig. 120, *A* to *D*.) This procedure is carried out as follows. An incision is made over the lateral aspect of the thigh near the junction of the shaft and the greater trochanter, just as in a Smith-Petersen nailing. After the bone in this region is exposed, an osteotome is driven across the shaft medially and somewhat upward, so that the osteotomy lies above (or proximal to) the lesser trochanter. The shaft is then pushed medially, allowing the lesser trochanter to lie just below the head of the femur. It is apparent that the cut end of the shaft is used essentially as a bone graft across the site of the nonunion of the neck. The greater trochanter and base of the neck unite with the shaft, and the shaft unites with the head and the proximal site of nonunion. Immobilization, using a one and one half hip spica, is carried out for eight weeks. Intertrochanteric osteotomy is permissable only if the head of the femur is viable.

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Occasionally, the head of the femur undergoes aseptic necrosis. This occurs in addition to the development of nonunion at the neck. In aseptic necrosis, the head as seen on the roentgenogram is denser than normal and may also be

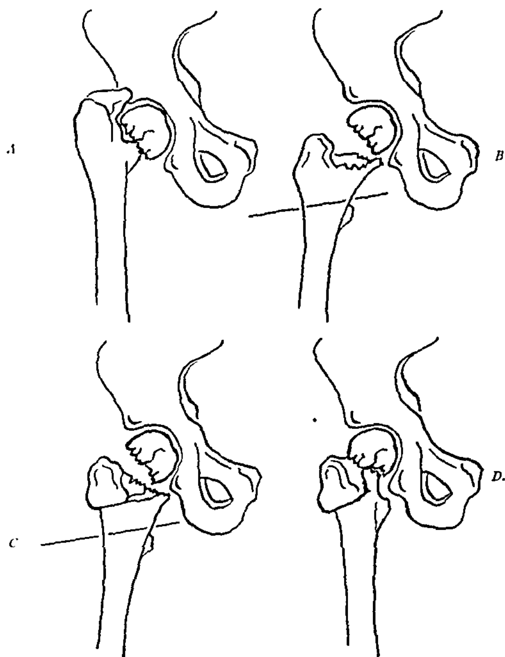


Fig. 120.—*A*, Nonunion of fracture of the femoral neck and absorption of the neck. *B*, Position of the fragments under traction on the operating table. Note line indicating plane of planned osteotomy. C, Intertrochanteric osteotomy has been completed and shaft has been forced medially. *D*, Later, when new bone has united the head to the shaft and the greater trochanter.

irregular and rough. If both aspetic necrosis and nonunion have developed, a reconstructive procedure rather than an intertrochanteric osteotomy is indicated. There are numerous reconstructive operations, all of which have the

following common principles: (1) the head is removed from the acetabulum, (2) the smoothed-off remnants of the neck support weight-bearing, and (3) the power of abduction is maintained by reconstitution of the lever through which the muscles inserting on the greater trochanter must act. This latter feature is accomplished by transplanting the greater trochanter with its attached muscles down onto the shaft or by wedging the greater trochanter laterally. The Whitman operation is a typical reconstructive procedure for nonunion, with or without aseptic necrosis. In this operation, an anterolateral exposure is made, the head is removed from the acetabulum, and the greater trochanter is osteotomized at its base and reattached lower down on the lateral aspect of the shaft.

Two other procedures in the management of a fracture of the femoral neck with nonunion and aseptic necrosis deserve special mention: use of a Vitallium cup and the use of a hip prosthesis. In the former the head of the femur is removed, the remnant of the femoral neck is covered with a Vitallium cup, and, at the same time, the abductor muscles are transplanted more distally down the shaft. If sufficient femoral neck does not remain after removal of the femoral head, the greater trochanter is covered with a Vitallium cup and placed in the acetabulum, and the abductor tendons are transplanted distally down the shaft.

The Judet prosthesis is composed of either a hard plastic material or stainless steel, is fashioned in the size and shape of a femoral head, and has a stem which extends distally into the femoral neck. The Moore prosthesis is composed of stainless steel, is made in the size and shape of the femoral head, and has a curving neck and a stem which are inserted through the neck of the femur down into the medullary cavity of the shaft. There are perforations in the stem portion of the prosthesis. Theoretically, the perforations should fill in with bone, and the prosthetic device is thereby held more firmly in place. Certain disadvantages in any hip prosthesis will be discussed under Hypertrophic Arthritis. Whether research and the development of new materials will overcome these disadvantages time alone will prove.

Intertrochanteric Fractures

An intertrochanteric fracture of the hip extends diagonally from above downward and medially between the greater and lesser trochanters—hence, the name intertrochanteric. (Fig. 121, *A*.) The patient usually complains of pain in the hip and the inability to stand or walk following an injury. This fracture usually occurs in a person 70 years of age (that is, a person ten years older than one who sustains a fracture of the femoral neck) and is sustained as a result of a fall upon the hip. The disability, the position of the affected extremity, and the physical findings are the same as in a fracture of the neck of the femur. The clinical signs are external rotation of the limb, shortening of the extremity, and the greater trochanter in the buttocks in a position above Nélaton's line. Reduction of the fracture is performed exactly as in a fracture of the femoral neck, either by a Whitman or a Leadbetter maneuver. (These maneuvers are described under Fracture of the Femoral Neck.)

An intertrochanteric fracture occurs in a region richly supplied by blood, and the fracture site has a relatively large area of cancellous bone to be opposed

in the reduction. Consequent upon these features, nonunion of an intertrochanteric fracture is very rare. However, the sheering forces are probably greater than those in a fracture of the femoral neck. Therefore, while union is the rule, a varus deformity is particularly prone to occur. The angle of the femoral shaft to the neck is normally 120 degrees. When this angle diminishes,

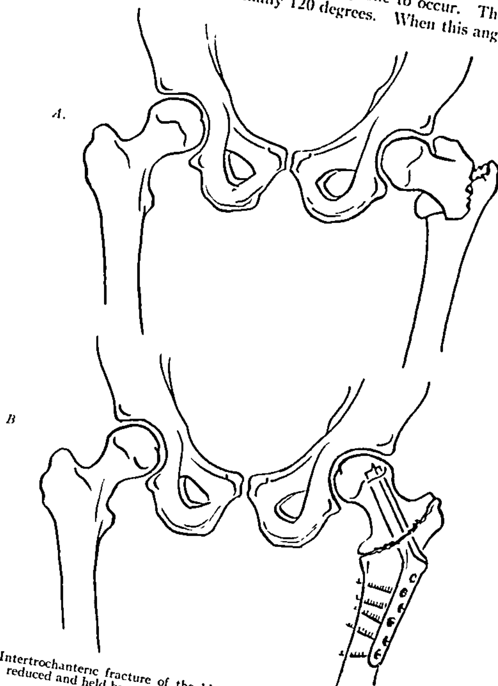


Fig 121 —*A*, Intertrochanteric fracture of the hip *B*, Intertrochanteric fracture of the hip reduced and held by a Smith-Petersen nail and Thornton plate

a varus deformity exists. In the reverse situation (that is, an angle greater than 120 degrees), a valgus deformity occurs.

Neither the ability to unite nor the danger of varus deformity rivals in nportance the excessive mortality rate which formerly accompanied this frac-

ture. Originally, an intertrochanteric fracture was treated by manipulative reduction and the application of a one and one half hip spica. In this treatment the mortality rate approached 50 per cent. This was probably due to the necessity for keeping a patient, especially an elderly one, in bed and immobilized in a large cast. When a patient of advanced age is immobilized for an extensive time, he is prone to develop bronchopneumonia, renal failure, cardiac decompensation, coronary thrombosis, or thrombophlebitis with pulmonary infarction. The newer methods of treatment are directed not only toward immobilization of the fracture, but also toward more mobility for the patient in general. Multiple pins inserted through the fracture site, a Smith-Petersen nail with an offset plate attached along the femoral shaft (sometimes called a Thornton plate) (Fig. 121, *B*), and Anderson's well-leg traction cast are some of the various methods which avoid prolonged immobilization of the elderly patient. These methods have reduced the previous distressing mortality rate to almost that for fractures of the femoral neck. One of the favorite methods in use today is the insertion of a Smith-Petersen nail, with an offset plate attached to the nail and along the femoral shaft. Such an appliance has its disadvantages. Sometimes the pin portion (within the neck and head of the femur) cuts through the neck anteriorly during the ensuing postoperative weeks and causes the fracture deformity to recur. Upon occasion, the surgical wound must be unusually long to accommodate the plate which is screwed to the femoral shaft. Another serious disadvantage is that the appliance can break at the junction between the pin and the plate. About twelve weeks are required for healing of the fracture, and then gradual weight-bearing is begun and continued for the next three to six months. An intertrochanteric fracture, then, is treated either by manipulative reduction and the application of a hip spica or by traction. The preferred method, however, is the insertion of a Smith-Petersen nail and Thornton plate, without applying a cast. Under this regime the patient is permitted free movement in bed during the twelve weeks the fracture mends or, if it is desirable, he is permitted early ambulation on crutches, without weight-bearing on the affected side.

A fracture of the femoral neck and an intertrochanteric fracture are quite different. A fracture of the femoral neck occurs in a patient about ten years younger than with an intertrochanteric fracture. The femoral neck is notorious for nonunion; the intertrochanteric fracture is famous for its ability to heal. Aseptic necrosis of the head of the femur may follow a fracture of the neck, while a varus deformity following healing is a common complication of an intertrochanteric fracture. The mortality rate in fractures of the femoral neck is not especially startling, but in intertrochanteric fractures it was almost 50 per cent until the recent advent of more effective treatment procedures.

Traumatic Posterior Dislocation of the Hip

Traumatic dislocation of the hip is not common, and a severe force is ordinarily required to produce the dislocation. It usually occurs in young adults. The patient complains of pain in the hip and the inability to stand or walk following an injury. When the femur is flexed and adducted, posterior dislocation

may occur if sufficient force is applied. A person who is sitting cross-legged in the front seat of an automobile and is suddenly thrown forward, striking the knee on the dashboard, may sustain a traumatic posterior dislocation of the hip. We emphasize that this discussion concerns *traumatic* and not *congenital* dislocation of the hip. Clinically, the signs of posterior dislocation of the hip are adduction of thigh, internal rotation of the leg, moderate flexion at the hip, marked *apparent* shortening of the leg, and the greater trochanter in a position above Nélaton's line. (Fig. 122.)



Fig 122 —Posterior dislocation of the hip Note position of greater trochanter indicated by the skin crayon line above Nélaton's line (running between the antero-superior iliac spine and the ischial tuberosity)

Reduction is obtained by using either the Allis method or the Bigelow circumduction method. In the Allis method the thigh and the knee are flexed to 90 degrees, with the patient in a supine position, while internal rotation is maintained; traction is exerted on the line of the flexed thigh, and the thigh and the knee are extended slowly In the Bigelow circumduction method the thigh and the knee are flexed to 90 degrees, with the patient in a supine position; traction in combination with adduction is exerted on the line of the flexed thigh; and the traction is continued while abduction, external rotation, and extension of the thigh are carried out simultaneously. After reduction, the patient is kept at bed rest for three weeks with the leg maintained in moderate abduction.

The complications in traumatic dislocation of the hip include damage to the sciatic nerve at the time of the injury and late aseptic necrosis of the head of the femur (that is, one to three years after the trauma). Should aseptic necrosis develop, with consequent roughening of the head and attendant arthritis, a cup arthroplasty affords the best chance for satisfactory function of the hip. The hip is approached anteriorly, and the femoral head is displaced from the acetabulum. The head is then smoothed with a cup-shaped reamer, covered with a Vitallium cup, and replaced in the acetabulum. Furthermore, when the femoral head is inspected, it is sometimes possible to excise the necrotic portion, leaving only the normal bone. Sometimes the major portion of the head is excised and only a shell remains. Then the cavity is packed with shavings of cancellous bone from the iliac crest, and thus the shape of the femoral head is reconstructed roughly. It is said that this bone graft resembles rose petals. The newly formed femoral head is covered with a Vitallium cup and replaced in the acetabulum. Another method in the management of aseptic necrosis is the replacement of the head by a prosthesis.

In filling out an insurance form the practitioner should estimate the total disability at twenty-four to thirty-two weeks and the partial disability at an additional eight to sixteen weeks. Under "Anticipated Loss" he may note that a limp may result and that aseptic necrosis of the femoral head may develop as a late complication.

Fractures of the Femoral Shaft

It is suggested that the discussion under Fracture of the Shaft of the Humerus be reviewed, since fractures of the shaft of the femur are comparable to them. Fractures of the femoral shaft present the same problems as fractures of a single long bone, and the types and treatment are similar to those of the humerus. (Fig. 123.) The presenting complaints are pain in the hip and the inability to stand or walk following an injury.

Transverse Fracture.—A transverse fracture with end-on opposition and little or no displacement is treated primarily by the application of a hip spica cast. However, because of the danger of angulation in the use of a cast it is preferable to use traction for four to six weeks. If the fracture is transverse but is displaced and the fragments override or angulate, traction is preferable at first to achieve reduction and allow some healing, and then a cast is applied.

Oblique or Spiral Oblique Fracture.—In an oblique or spiral oblique fracture the fragments will usually override if the fracture is treated primarily with the application of a cast. Therefore, traction is employed at first, and a cast is applied later.

Comminuted Fracture.—If the comminution consists of many fractures, the use of traction is more likely to achieve stability than is the application of a cast. If one large, free, uncontrollable fragment constitutes the comminution, open reduction, internal fixation, and the application of a cast are the procedures of choice. Open reduction is used in a compound fracture, in a fracture which has not been aligned by traction or in a comminuted fracture in which the fragments cannot be readily controlled and are large enough to require consideration.

A possible method of therapy consists of using transfixing pins combined with external fixation, with or without open reduction. About ten weeks are required for healing.

Intramedullary pinning is another method of treatment in a fracture of the shaft of the femur, whether the fracture site is transverse, oblique, or comminuted, with a large central fragment. It is usually performed in conjunction with an open reduction in order to maintain the bone fragments in the proper position while the intramedullary pin is inserted distally through the greater trochanter into the distal metaphysis of the femur. This method should be performed only by an especially experienced orthopedic surgeon.

In general skeletal traction in the treatment of a simple transverse, oblique,

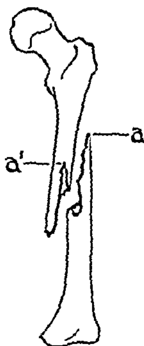


Fig. 123.—Oblique fracture of the shaft of the femur with separation of the fragments and overriding, *a* should be positioned at *a1* Such a fracture is unstable and even if well reduced tends to slip into deformity again unless held by internal fixation or traction.

or spiral fracture, until sufficient callus has formed to warrant the application of a one and one half hip spica, produces a satisfactory result.

In a child under 6 years of age with a fracture of the femoral shaft, Bryant's vertical suspension method is the procedure of choice. In this method both the affected and unaffected extremities are placed in skin traction and suspended from an overhead frame, with the thighs flexed to 90 degrees on the abdomen and with the knees in extension. Enough traction should be maintained to just barely raise the buttocks from the bed A child under 6 years of age usually tolerates this method exceedingly well, but it is unsuitable in an older child. The physician should test the unaffected extremity by a straight leg raising test to ascertain that the child can tolerate the position necessary to this method. About six to eight weeks are required for healing.

In filling out an insurance form the practitioner should estimate the total disability at eighteen to twenty weeks and the partial disability at an additional eight to ten weeks. Under "Anticipated Loss" he may note that stiffness in the knee may occur.

NONTRAUMATIC DISORDERS OF THE HIP

Complaint	Likely Diagnoses	Page
Pain in hip and limp unassociated with acute trauma	(1) Malum coxae senilis	229
	(2) Hypertrophic arthritis of hip	231
	(3) Aseptic necrosis of the femoral head	233
	(4) Rheumatoid arthritis	234
	(5) Trochanteric bursitis with or without calcification	235
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Lurching, tiring gait	(1) Post-poliomyelitic muscle weakness around hip	236

Malum Coxae Senilis

Malum coxae senilis is a type of hypertrophic arthritis. However, the term is frequently applied to conditions which originally were quite distinct from one another and from hypertrophic arthritis as it is ordinarily understood. The patient complains of pain in the hip and a limp, both of which are unassociated with acute trauma.

Slipping capital femoral epiphysis may produce as its end result a misshapen femoral head, with irregularity of the acetabulum as a secondary manifestation. Sclerosis or an increased density of the femoral head, together with spurs of exuberant soft bone of poor quality, are also commonly present. Such a condition is quite logically called malum coxae senilis despite the fact that it occurs in a young patient in the 25-to-35-year age group. Congenital dislocation of the hip which was not treated or was treated unsuccessfully may produce an end result quite similar to that produced by a previous slipped capital femoral epiphysis, in so far as the pathologic changes in the femoral head and the acetabulum are concerned. This too is considered malum coxae senilis—again in spite of the young age at which it occurs (25 to 35 years). Legg-Perthes' disease which heals in deformity can eventually produce the same condition. Suppurative arthritis, contracted and treated years previously, but with resultant irregular destruction of the femoral head, may eventually produce malum coxae senilis. Malum coxae senilis is not a specific condition, but rather a group of pathologic changes which consist of irregularity of the femoral head, narrowing of the joint space, irregularity of the acetabulum, and sclerosis and bony proliferation of the femoral head, the acetabulum, and sometimes the femoral neck. (Fig. 124, *A*.) It must be emphasized that in the type of *malum coxae senilis* which occurs in the young adult the etiologic factor may be a previous slipped capital femoral epiphysis, Legg-Perthes' disease, congenital dislocation of the hip, previous infection, or previous trauma. The usual hypertrophic arthritis occurs in the older patients who have no history of a disturbance of the hip during childhood.

A possible method of therapy consists of using transfixing pins combined with external fixation, with or without open reduction. About ten weeks are required for healing.

Intramedullary pinning is another method of treatment in a fracture of the shaft of the femur, whether the fracture site is transverse, oblique, or comminuted, with a large central fragment. It is usually performed in conjunction with an open reduction in order to maintain the bone fragments in the proper position while the intramedullary pin is inserted distally through the greater trochanter into the distal metaphysis of the femur. This method should be performed only by an especially experienced orthopedic surgeon.

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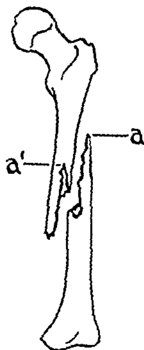


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or spiral fracture, until sufficient callus has formed to warrant the application of a one and one half hip spica, produces a satisfactory result.

In a child under 6 years of age with a fracture of the femoral shaft, Bryant's vertical suspension method is the procedure of choice. In this method both the affected and unaffected extremities are placed in skin traction and suspended from an overhead frame, with the thighs flexed to 90 degrees on the abdomen and with the knees in extension. Enough traction should be maintained to just barely raise the buttocks from the bed. A child under 6 years of age usually tolerates this method exceedingly well, but it is unsuitable in an older child. The physician should test the unaffected extremity by a straight leg raising test to ascertain that the child can tolerate the position necessary to this method. About six to eight weeks are required for healing.

of several types of operation. An arthrodesis of the hip may be carried out. An immovable joint is painless, stable, and serviceable. Unfortunately, patients frequently fail to see the wisdom of an arthrodesis which produces a "stiff" joint. A second procedure (often advised) is a subtrochanteric osteotomy, which alters the weight-bearing surface. Perhaps the best operative measure is a Vitallium cup arthroplasty. The Smith-Petersen iliofemoral approach to the hip is used; that is, an incision is made along the anterior one third of the iliac crest and at the anterosuperior iliac spine it is curved downward and somewhat medially between the sartorius and tensor fascia femoris muscles. The iliacus muscle is stripped subperiosteally from the inside of the ilium and retracted medially. The gluteal muscles are turned laterally and posteriorly from the lateral wall of the ilium. The interval between the sartorius and tensor fascia femoris is developed until the direct head of the rectus femoris is encountered. The latter is severed near its attachment to the anteroinferior iliac spine and reflected distally. At this point the anterior aspect of the acetabulum, the femoral neck, the joint capsule, and the reflected head of the rectus femoris are in the operative field. The capsule is incised, and the diseased femoral head is dislocated by manipulation. Using a bell-shaped instrument lined with cutting blades, the operator smoothes the femoral head. Excessive bony spurs are cut away from the neck. A Vitallium cup of the proper size is placed over the head, the dislocation is reduced by manipulation, and the wound is closed in anatomic layers. (Fig. 124, *B*)

Following a cup arthroplasty of the hip, physiotherapy and the cooperation of the patient are of great importance to successful rehabilitation, just as after arthroplasty anywhere else in the body. Commonly, the extremity is placed in traction to relieve postoperative muscle spasm and to maintain a certain degree of immobilization Motion is started when the wound is healed—on about the tenth postoperative day. Motion is passive at first, but graded active exercises are soon begun. Weight-bearing on crutches is started about the fourth week after the operation, and the crutches are discarded about four months thereafter. Range of motion ordinarily increases, and pain may be markedly diminished Postoperative dislocation of the hip, dislocation of the Vitallium cup, wound infection, or periarticular fibrosis which limits motion are among the possible complications which could cause the operation to fail. It should also be realized that pain may be unrelieved following an arthroplasty, and pain is one of the prime reasons why a patient seeks medical aid.

A prosthesis (see Fig. 119) can be used in the treatment of malum coxae senilis This method of treatment is discussed under Hypertrophic Arthritis of the Hip.

Hypertrophic Arthritis of the Hip

We have presented malum coxae senilis as an entity, but many orthopedists make no distinction between it and hypertrophic arthritis of the hip. However, there are certain reasons why we believe it is correct to distinguish between the two. We wish to emphasize the fact that disturbances of the hip occurring in children do not necessarily end in childhood and that only the doctor who

Clinically the patient, who frequently is young, complains of pain and stiffness in the hip and has a limp. There is limitation of almost any motion of the hip, both active and passive. The roentgenograms confirm the diagnosis. A history of some previous disorder of the hip is usually obtained, and the presenting condition may be very disabling.

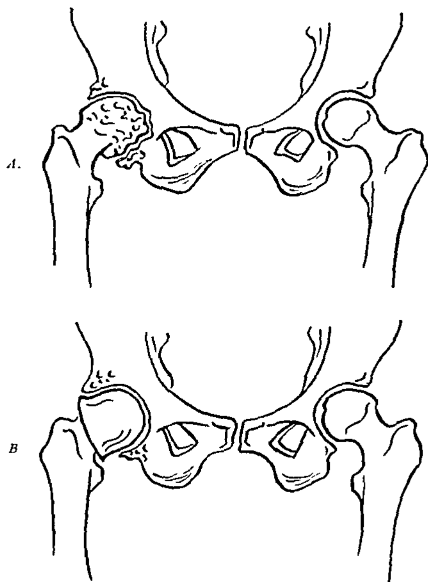


Fig. 124 —*A*, Malum coxae senilis of the hip *B*, Malum coxae senilis having been treated by Vitallium cup arthroplasty

The tendency is to treat malum coxae senilis conservatively in older patients and radically in younger patients In conservative treatment activity is limited to prevent excessive use of the hip Therapeutic measures, such as heat, massage, and the use of a cane or crutches to protect the hip from weight-bearing, are instituted. Intra-articular injections of Hydrocortone are used to advantage. In radical treatment operative therapy is performed. There is a choice

prostheses. In this procedure the head of the femur is excised and replaced by a metal prosthesis in the shape and size of the normal femoral head. There are several disadvantages in a hip prosthesis, and in time perhaps the development of different prosthetic materials will overcome many of these disadvantages. Probably no metal object can exactly duplicate the size and shape of the normal femoral head. Furthermore, since the acetabulum has been distorted by the disease, a prosthesis in a normal shape is actually incongruous with it. Therefore, the prosthesis possesses mechanical abnormalities which can produce further hypertrophic conditions in the body. When metal is placed under stress in its relationship to bone, bone absorption is possible, and the prosthesis may become loose. The most important objection to the use of a prosthesis, however, is the lack of affective alternative treatment in the event of the failure of the prosthesis. If it has been inserted and if the patient is still disabled by pain, limp, or weakness in the hip, the difficulties are extreme. Very few procedures then remain which offer the patient any relief. In such a situation, the head of the femur and perhaps much of the femoral neck has already been sacrificed. Consequently, an arthrodesis, a subtrochanteric osteotomy, and a cup arthroplasty cannot be performed. In view of these facts, if a prosthesis is used at all for a nontraumatic disability of the hip, it should be used in elderly patients whose remaining years of life could be so few that these disadvantages become relatively unimportant, rather than on young patients whose life expectancy is too great to risk the possibility of future disabilities which cannot be corrected.

Aseptic Necrosis of the Femoral Head

A traumatic dislocation of the hip in the young adult frequently ruptures the ligamentum teres, the joint capsule, and the accompanying arteries. The patient complains of pain in the hip and a limp. At the age (20 to 30 years) at which traumatic dislocation commonly occurs, much of the vascular supply to the femoral head is derived from the vessel on the ligamentum teres and the posterior capsular vessel. Therefore, the femoral head is in danger of undergoing aseptic necrosis due to an inadequate blood supply. A fracture of the femoral neck or an intertrochanteric fracture sustained in childhood or young adulthood is usually the result of excessively severe trauma. Following such a fracture, aseptic necrosis of the femoral head very commonly ensues because of interference with the blood supply. Less commonly, the same complication arises in the *aged patient* who has sustained a fracture of the femoral neck or who is suffering from nonunion of a previous fracture of the neck of the femur.

Bone which is deprived of its blood supply becomes sclerotic at first. On the roentgenograms the femoral head appears denser than the surrounding bone, although no change in its contour can be observed. Gradually the necrotic bone may be replaced by new bone through the process of creeping replacement. That is, new osteoblasts form in the dense, necrotic trabeculum and throw down a matrix. Eventually, a necrotic trabeculum is entirely surrounded by osteoid tissue. Gradually the injured trabeculum is absorbed, and the osteoid tissue calcifies. During the time that the necrotic trabeculum is being absorbed,

treats the patient both as a child and as an adult will have the proper perspective concerning the potential dangers in hip affections occurring during infancy and childhood. Furthermore, the pathologic changes in the femoral head, neck, and acetabulum due to hypertrophic arthritis do not necessarily arise because of an antecedent disturbance. Hypertrophic changes can occur in the hip just as they do in the knee, the back, or the distal interphalangeal joints. Therefore, malum coxae senilis, as we use the term, refers to pathologic changes in the hip due to previous derangements in childhood which are primarily manifest in young adulthood; that is, from 25 to 35 years of age. Hypertrophic arthritis, as we use the term, refers to pathologic changes which occur without previous derangements in childhood and are manifest mainly in elderly persons; that is, over 60 years of age.

Patients with hypertrophic arthritis of the hip complain of progressive pain and stiffness around the hip, and a limp. Sometimes the pain is in the buttocks and at other times in the groin, and the condition is not due to acute trauma. Examination usually reveals a shortening of the extremity which is more apparent than real. There is a tendency toward flexion and adduction contracture. If the patient lies supine on the examining table and flexes the unaffected thigh as far as possible on the abdomen, he will not be able to extend the affected thigh so that it lies flat on the examining table (flexion contracture). Furthermore, if the unaffected extremity is placed in wide abduction, the affected extremity cannot usually be abducted at all from the neutral position (adduction contracture). Although we speak of flexion and adduction contracture, it should be realized that these limitations of motion may not be due alone to soft tissue impairment, but also to a bony block resulting from incongruous joint surfaces. Internal and external rotation of the thigh is badly impaired. Flexion is usually maintained better than any other motion. The patient is usually unable to extend the thigh, and on examination the limp is apparent. Roentgenograms, which show the characteristic changes of narrowing of the joint space, the irregularity of the contour of the femoral head and acetabulum, the presence of bony spurs, and the areas of sclerosis and rarefaction within both the femoral head and neck and the acetabulum, complete the examination.

Conservative treatment consists of the administration of salicylates, the application of heat to the joint, and the protection of the joint from normal function through decreased activity and the use of a cane or crutches. The intra-articular instillation of hydrocortisone may give periods of considerable symptomatic relief. Aspiration of the hip joint is more difficult than the aspiration of many other joints, and the physician must be experienced in this procedure to be successful in the injection of the medication into the hip joint.

Radical treatment of hypertrophic arthritis of the hip is operative. One method, perhaps the best, is cup arthroplasty. This procedure and its aftertreatment have been described under Malum Coxae Senilis. Arthrodesis, although a possible method, is probably more successful in young patients who have a malum coxae senilis than in elderly patients who have hypertrophic arthritis. Another method of radical treatment is the use of one of the hip

fever is ruled out) or on the presence of stigmas of the disease, such as swollen proximal interphalangeal joints or a stiff low back, elsewhere in the body.

In the early stages rheumatoid arthritis of the hip is managed in the same general manner as is the disease in any other part of the body. The patient is advised to get more rest, both mental and physical. Gentle physical therapy to maintain motion is instituted, and a program of exercises designed to increase or maintain hip motion is prescribed. General bodily resistance is built up. If necessary, intra-articular Hydrocortone is administered, or treatment with ACTH and cortisone is given. If the joint has been destroyed, or nearly destroyed, operative procedures are usually performed. Corrective osteotomy to allow proper hygienic care of the patient can be performed. Vitallium cup arthroplasty may be indicated, particularly if both hips are severely limited, since such a disability is very grave.

Trochanteric Bursitis With or Without Calcification

Infrequently an adult complains of a nontraumatic pain in the hip which he is careful to localize in the region of the greater trochanter or on the lateral aspect of the thigh. Examination reveals very acute tenderness which is sharply localized in a small area just over the greater trochanter of the femur at the lateral aspect of the hip. Both passive and active motions of the hip joint are painful, but there is no true loss of motion in the hip, as in malum coxae senilis or aseptic necrosis of the femoral head. Therefore, the physician should suspect that the condition is a bursitis. The x-ray pictures may reveal a calcific deposit just lateral to the greater trochanter; if this condition is present, x-ray therapy is a good conservative treatment. X-ray therapy for calcific bursitis in this region, as in calcific bursitis of the shoulder, should be given daily for approximately five to seven treatments. The patient should be warned that a flare-up of pain will probably occur within twelve hours after the first treatment. Furthermore, an ice bag is applied to the lateral aspect of the hip, and heat is studiously avoided. Heat ordinarily aggravates the pain. Medication to alleviate pain is given, particularly during the first twelve to twenty-four hours, when the flare-up is likely to occur.

If the signs of bursitis of the greater trochanter are present and if the roentgenograms do not reveal a calcific deposit, it is advisable to inject Novocain and Hydrocortone into the tender area. Again, it should be remembered that heat causes an aggravation of pain, while cold aids in diminishing pain. Similarly, as in x-ray therapy, Novocain injected into an area of acute bursitis, either with or without calcification, is likely to cause a flare-up of pain within twelve hours after the injection. The patient should be warned to expect this, and medication for the pain is prescribed. Ordinarily, only one or possibly two injections are needed to control the process in this region.

Snapping Hip

If the patient complains of a snap in the hip, the affection is snapping hip. In this disorder the fascia lata overlying the greater trochanter is taut, thick-

roentgenograms, which reveal areas of rarefaction scattered throughout the otherwise dense head, are taken at intervals. Furthermore, there is sometimes irregularity in the surface of the femoral head. After the passage of enough time, the necrotic head may be entirely replaced by the new bone. Aspetic necrosis does not appear until several months to two or three years after the original injury, and several years are required for the head to be replaced by the very slow "creeping replacement" process.

Clinically the patient, usually a young adult male, complains of pain and limitation of motion in the hip which has been injured within the previous two years The roentgenograms may show a variety of changes. There may be uniform density of the entire femoral head without distortion of contour, a generally dense femoral head with areas of rarefaction, or a badly misshapened, irregular femoral head containing both dense and rarefied areas.

It is imperative that a series of roentgenograms be taken over a long period of time during the follow-up care of patients with traumatic dislocation of the hip or of *young adults* who sustain a fracture of the femoral neck or of the intertrochanteric region.

If the aseptic necrosis is discovered in its incipient stage, conservative therapy in which the activities are restricted, a walking brace is applied, and crutches are used may suffice. If the process is well developed, radical therapy is indicated. Vitallium cup arthroplasty is the treatment of choice. This operation is described in detail under Malum Coxae Senilis. Briefly, after the femoral head is exposed, the necrotic portion is removed, and the resultant cavity is packed with strips of cancellous bone graft. The Vitallium cup is then placed over the reconstructed femoral head and replaced in the acetabulum.

Rheumatoid Arthritis

In a young person a complaint of spontaneous pain in the hip suggests that *the patient may have rheumatoid arthritis. If the patient is a woman, it should* be determined whether she has had past episodes of painful, swollen proximal interphalangeal or metacarpophalangeal joints. Generalized rheumatoid arthritis which involves the small joints of the hands and eventually the large joints, such as the hip, is especially common in young women. Yet if the presenting complaint is pain in the hip, the patient may have forgotten past episodes of pain in the hand, or she may not connect pain in the hip with pain in the hand. Therefore it is necessary that the physician inquire about previous episodes of pain in the hand. If the patient is a man, it should be determined whether he has experienced past episodes of low back pain. In a young man an early occurrence of Marie-Strümpell arthritis affecting the low back may be associated with arthritis of the hip but not of the hands, therefore, the possibility that the presenting complaint of pain in the hip may be due to Marie-Strümpell disease should be kept in mind.

Diagnosis can be confirmed if the roentgenograms are positive. If the x-ray pictures are negative (as they frequently are in the early stages), then diagnosis is made on a history of migratory arthralgia (provided rheumatic

Chapter Six

*Disturbances of the Back**

Disturbances of the back present so many difficulties in differential diagnosis that many approach these problems with somewhat of an attitude of defeatism. It may be true that there are a number of different causes of back pain and that at times differential diagnosis may be exceedingly difficult. However, careful attention to history of the disturbance and to examination, which is carefully correlated with an understanding of the significance of the signs elicited should make the diagnosis and treatment of disturbances of the back a great deal less difficult. In our approach to the subject, anatomy of the back will be presented first, and then differential diagnosis in association with orthopedic examination of the back will be discussed. By following the reasoning of such examination and interpreting the signs elicited, diagnosis of the different disturbances should be clear cut. Once diagnosis has been established, treatment is relatively standard. The conditions of the back will be discussed in three categories: (1) traumatic injuries to the back, (2) nontraumatic disorders of the back, and (3) exaggeration and malingering in back pain.

ANATOMY

The number of bodies in the vertebral column vary somewhat. Usually there are seven cervical, twelve thoracic, and five lumbar vertebrae. The sacrum is a fused mass of five bodies, and there are five coccygeal segments The general characteristics of a vertebra are as follows. There is a cylindrical body with a posterior bony arch. A spinous process in the midline and two transverse processes directed laterally project from the posterior arch. Two inferior and two superior articular facets (zygapophyseals) articulate with the bony arches of the vertebra above and the one below. These facets help to form the foramina, the bony tunnels through which the nerve roots pass on their way to peripheral parts of the body. In between the vertebral bodies is a nucleus pulposus. An anterior longitudinal ligament of great strength binds the anterior surfaces of the verte-

*See Chapter 1, Diseases or Affections in Childhood, (page 90), for other conditions of the back

ened, and roughened. As the band of fascia lata moves across the greater trochanter, it catches at first and then is released suddenly with a loud, audible snap. Patients can ordinarily produce the snap at will. The condition becomes painful at times. In the operative treatment for this condition, the portion of the fascia lata overlying the greater trochanter is resected.

Post-Poliomyelitic Muscle Weakness Around the Hip

A complaint of a lurching, tiring gait could be due to several conditions—previous congenital dislocation of the hip, previous septic hip with destruction of the femoral head and absorption of the femoral neck, or a previous nonunion of a fracture of the femoral neck. However, one of the commonest causes is weakness surrounding the hip joint following an attack of anterior poliomyelitis. If the roentgenograms and adequate examination of the muscle power in the hip reveal none of the other mechanical causes of the lurching gait, the condition is due to muscle weakness, fundamentally. In the conservative treatment, an ischial weight-bearing type of brace is applied. In the radical treatment, the neighboring powerful muscles, such as the erector spinae or the obliques abdominis externus, are transferred to the weakened area. If the paralysis is extensive enough to warrant it, an arthrodesis or a subtrochanteric osteotomy is performed. See Chapter 1, Diseases or Affections in Childhood, under Post-Poliomyelitic Weakness Around the Hip and Anterior Poliomyelitis for detailed management of the condition.

is present, the extent of examination is necessarily limited (that is, the patient is not requested to stand, to test for back motion, etc.). In the orthopedic examination of the back certain general principles are followed to obtain information which is interpreted on the basis of the history. Confirmation is made later from the roentgenograms.

First, inspection is carried out to determine whether the normal curves are present, whether the shoulders are shifted laterally in relation to the pelvis (list, protective scoliosis), and whether a gibbus is present. Since this is an examination of an injured back, flattening of the normal lumbar lordosis should be interpreted to be muscle spasm. The muscle spasm can arise from a fracture, a strain, a ruptured disc, etc.; that is, it is nonspecific, but it points to a genuine, painful, and relatively severe disturbance. If inspection reveals that the shoulders are shifted in relation to the pelvis (and the history indicates that they were not displaced prior to injury), then a rupture of the intervertebral disc or an acute facet syndrome is the most likely diagnosis. Should inspection reveal a gibbus, then a relatively severe compression fracture of a vertebral body is quite likely.

Second, palpation is carried out to determine the location of tender areas. This is done with the patient erect unless the history indicates that there may be a fracture; under such a circumstance the patient lies on his side. Palpation is carried out directly over the spinous processes, over the interspinous ligaments between the spinous processes, over the insertions of the erector spinae muscles overlying the sacrum (and to the sides of the midline), and over the erector spinae muscle masses (overlying the lumbar transverse processes). If the greatest tenderness is on the spinous process itself (not the interspinous ligament), a compression fracture is the likely diagnosis. If the tenderness is over the interspinous ligament, strain, a rupture of the nucleus pulposus, and an acute facet syndrome are to be kept uppermost in mind. Tenderness overlying the sacrum is evidence of muscle strain. Rather marked tenderness in the region of the muscle mass of the erector spinae indicates the possibility of a fracture of the transverse processes.

Third, the range of motion is tested, with the patient erect; this test is omitted if it is suspected that a fracture has occurred. Both the range of forward flexion and the manner of its accomplishment are observed. The normal person can bend forward, with the knees straight, so that the finger tips reach at least half way down the shins. In forward flexion the head and neck start the process, and the other segments of the back from the shoulders downward follow in orderly sequence. Each successive portion of the spine contributes its share of flexion; that is, movement of each segment is observed. In the injured back, forward flexion is usually limited so that an arc of only 30 to 40 degrees is made before pain and spasm halt the action. Furthermore, not only may there be limitation of the range of motion as a whole, but also motion in a given segment may be lacking; that is, one portion of the back moves en bloc and does not exhibit orderly consecutive flexion. Limitation of forward flexion, with the attendant loss of segmentation of movement in a given area, is a nonspecific sign and simply indicates that an organic disturbance of significant proportions is present. After the range and style of forward flexion is observed, lateral flexion

bral bodies together. The normal curves of the vertebral column consist of the cervical spine, which is concave posteriorly (lordosis), the thoracic spine, which is concave anteriorly (kyphosis), and the lumbar spine, which has a normal lordosis. Directly on each side of the midline are two large and powerful muscle masses which arise from the sacrum and pass cephalad—the erector spinae muscles. In the midline posteriorly in between each spinous process are the interspinous ligaments.

HISTORY AND DIFFERENTIAL DIAGNOSIS

The history of the disturbance is the key factor in establishing likely diagnoses, and the examination is an aid in the selection of the proper diagnosis.

Let us consider the category of injuries due to trauma. In these conditions, the *type* of injury is the factor in the history which should guide the physician in his differential diagnosis. There are a few typical situations encountered:

1. Back pain following an automobile accident in which the patient has *obviously* sustained *severe trauma*, resulting in a compression fracture of a vertebral body, a fracture of the pelvis, or a fracture of a transverse process.
2. Back pain following a fall from a considerable height (10 to 20 feet or more) in which the patient lands on the feet and rolls forward, flexing the spine, and sustains a compression fracture of a vertebral body.
3. Back pain following a fall from a considerable height in which the patient *lands on the buttocks, thereafter flexing the spine, and sustains a compression fracture.*
4. Back pain after lifting of a heavy object in which the muscles, ligaments, or joints of the back are strained.
5. Back pain and /or sciatica after the lifting of a heavy object in which a rupture of the nucleus pulposus occurs.
6. Back pain and list following certain positions of the back in which strain and stress were not especially prominent features and which result in an acute facet syndrome.

It is apparent that in essence differential diagnosis is influenced by whether some type of fracture exists, whether the ligaments, muscles, or joints of the back are strained, whether a ruptured disc is present, or whether an acute facet syndrome is present. In a fracture the history is of severe injury; in strain or a ruptured disc the history is of much less violence; and in an acute facet syndrome the history is of an awkward positioning of the back rather than of stress and strain. Therefore, by considering the nature of the history the doctor should be able to decide into which category the ultimate diagnosis will fall.

EXAMINATION OF THE BACK

The fundamental objective of an orthopedic examination of the back is to reach a correct diagnosis. Many of the signs are nonspecific, as is true of any other part of the body

Examination is carried out after the physician has made a tentative diagnosis based on the type of history elicited. If the presumption is that a fracture

of the trauma is determined, and the orthopedic examination is made. The x-ray pictures reveal the type of fracture (if any) present and are generally negative if there is a strain, a rupture of the disc, or an acute facet syndrome. If any of the latter three conditions exist, the roentgenograms at most show a flattening of the normal lumbar lordosis (due to muscle spasm) or a narrowing between two vertebrae (consistent with the plain film findings of degeneration or rupture of a disc.)

TRAUMATIC INJURIES TO THE BACK

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Fractures of the Pelvis

Although fractures of the pelvis are not ordinarily included in a discussion of back pain, the fact remains that a patient who is subjected to severe violence, sustaining a fractured pelvis, complains of combined back and abdominal pain. Very often the pain in the back is so severe that the patient states that he "feels he is splitting in two." In fact, back pain as a result of a fracture of the pelvis may be more urgent and pressing than back pain due to a compression fracture of the back. Therefore, if a patient who has been subjected to severe trauma complains of back and abdominal pain, the likely diagnosis may not be a disturbance of the vertebral column per se but rather a fracture of the pelvis.

Certain general facts about fractures of the pelvis will be presented before the specific types of injuries are discussed.

The incidence of pelvic fractures is increasing. Since severe violence is required to fracture the pelvis, the increase in violent accidents due to the acceleration in modern industry and transportation may be the cause. Formerly, the injury occurred more commonly in men, but recently the incidence of the injury is increasing among women.

Shock is a frequent complication. The patient should be carefully watched for signs of impending shock and measures taken to prevent its occurrence or to treat it if it is already present.

to each side is noted. Limitation of motion both to the right and to the left are likely if bilateral muscle and ligament strain is present. If muscle strain on one side only is present, then lateral flexion *away* from the affected side is likely to be limited and painful and to be accompanied by palpable and observable muscle spasm. Conversely, lateral flexion *toward* the side of muscle or ligamentous strain is *not* likely to be limited or painful. Lateral bending away from the injured side places a strain on the already strained muscles and ligaments, with resultant pain whereas lateral flexion toward the injured side relaxes the painful muscles and is not likely to produce additional pain. This is well to remember, since the reverse situation is true in general in a ruptured intervertebral disc; that is, lateral flexion toward the side of a ruptured disc is likely to increase pain whereas lateral flexion away from the injured side is not likely to cause pain. The result of lateral flexion in an acute facet syndrome should also be noted. In this condition, lateral flexion toward the same side to which C-7 is abnormally shifted is likely to be normal and not particularly painful, while lateral flexion to the side opposite the shift is likely to be limited and painful.

Fourth, the examination proceeds with the patient supine. Straight leg raising is performed. With the patient supine, the examiner lifts the leg upward while the knee remains extended. In general, in a normal person, the leg can be raised through an arc of at least 60 degrees. In a person with an injured back, limitation frequently occurs on either one or both sides. One leg is often used to compare the loss in the other leg. In fractures and severe bilateral muscle strains limitation of straight leg raising on both sides is expected. In a unilateral muscle strain and ruptured disc unilateral limitation is more common than bilateral. After straight leg raising is tested the so-called lumbosacral test is performed. In this maneuver both thighs are flexed on the abdomen (with both knees in flexion), and the flexion is increased by gentle to moderate pressure. The supposition is that this maneuver places stress on the lumbosacral joint. Since this test elicits pain in several different types of injury to the back, it is rather unreliable as a specific test.

Fifth, certain neurologic tests of the lower extremities complete the examination. The ankle-jerk and knee-jerk tests are performed. Sensitivity to pinprick is tested, especially over the dorsum of the feet, in the lateral aspects of the feet, and in the areas posterior to the lateral malleoli of the ankles. The power of extension of the great toe (extensor hallucis longus) is tested and compared with the opposite side. The power to dorsiflex and to evert the foot is tested on each side. These tests are performed primarily if it is thought that there is a rupture of the intervertebral disc. (If a compression fracture of a vertebral centrum is suspected, a complete muscle power examination, together with sensory and reflex tests, should, of course, be made.) In a patient with a ruptured disc, diminution in or absence of ankle jerk or knee jerk is common. Diminution of sensitivity to pinprick on the dorsolateral aspect of the foot and ankle is also common. A delicate sign indicating a ruptured disc is weakened ability to extend the great toe on the affected side.

To be of the most benefit, the roentgenograms should not be taken until after the history is obtained, the likely diagnosis based on the type and severity

Treatment for the fractures just discussed appears to be almost casual. The following types of pelvic fracture, however, require more strenuous treatment as well as a longer period of immobilization (that is, from six to eight weeks).

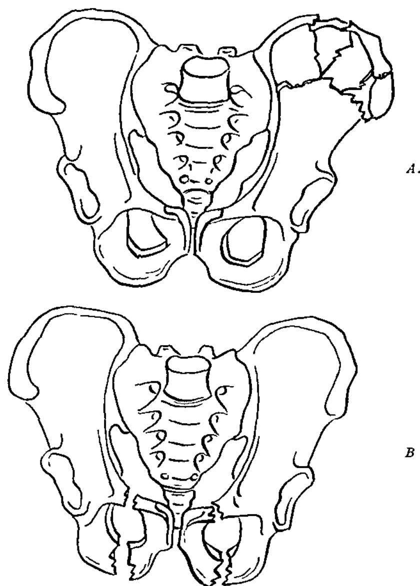


Fig 125.—*A*, Fracture of the iliac wing *B*, Double vertical fracture of the pelvis.

Double Vertical Fractures of the Superior and Inferior Pubic Rami Bilaterally.—These really consist of four separate fractures occurring so that the symphysis pubis is free. (Fig. 125, *B*.) A pelvic sling is commonly used in treatment of such an injury to suspend the patient just above the bed. The sides of the sling are arranged so that no undue medial compression is exerted on the pelvis.

Malgaigne's Fracture.—This is a double vertical fracture of the pubic rami on one side associated with a dislocation or fracture-dislocation of the sacro-

It should also be realized that multiple injuries are commonly present in a patient who sustains a fractured pelvis because of the severity of the violence to which the patient has been subjected. Not only should a search be made for fractures in the rest of the body, but also the thorax and abdomen should be carefully examined. Rupture of an intra-abdominal viscus not infrequently occurs in conjunction with a fracture of the pelvis. The urethra and urinary bladder are especially likely to be injured. Therefore, one of the first considerations in treating a patient with a fractured pelvis is the condition of the genitourinary tract. An attempt is made to ascertain whether the patient can void spontaneously. If he can, the urine should be examined for the presence of blood. If he cannot, it is necessary to determine whether the urethra or the bladder is lacerated. Treatment of such a condition is best managed by the urologist.

In summary, the management of a patient with a fracture of the pelvis includes treatment for shock, the discovery and treatment of assiocated intra-abdominal or intrathoracic catastrophes, and treatment of the fracture per se.

A curious feature of a fracture of the pelvis is that the functional result does not seem to be dependent upon how well the fracture has been reduced. Many patients who have gross malunion of a fracture, as shown on the roentgenograms, have no residual pain, whereas many who have an anatomically aligned fracture experience pain and disability later.

The clinical diagnosis of a fracture of the pelvis can be presumed upon the basis of the history and physical findings. In examining the pelvis, certain maneuvers are helpful. Local tenderness can be sought, but due to the deep location of the pelvic bone it is more effective to exert stress and strain. In one maneuver *gentle* anteroposterior pressure is exerted over the symphysis pubis. Next, the heels of the examiner's hands are placed laterally on the iliac wings and *gentle* pressure toward the midline is exerted. Last, the iliac crests are grasped in the region of the anterosuperior iliac spines and are forced gently outward and posteriorly. If a fracture of the pelvis is present, at least one of these three manuevers produces pain. Roentgenograms are taken to confirm the clinical diagnosis.

Although many combinations and types of fractures of the pelvis are possible, only some of the more common ones are considered here.

Fracture of the Iliac Wing.—This fracture is frequently comminuted and the fragments tend to be displaced upward and outward. (Fig. 125, *A*.) Treatment consists of a swathe around the affected part and bed rest for about four weeks. Immobilization is used simply to relieve pain and to afford the patient a sense of support.

Isolated Avulsion Fracture of the Anterosuperior Iliac Spine.—In this fracture the fragment is usually displaced downward due to the pull of the sartorius muscle Bed rest, with the thigh in a position of flexion, is ordinarily adequate treatment.

Single Vertical Fracture of the Superior or Inferior Pubic Ramus.—This is one of the commonest fractures. There is most often no displacement of fragments. Treatment is directed toward making the patient comfortable and giving him a feeling of support. Therefore, bed rest, with a swath for the injured part, is ordinarily sufficient treatment. Recovery usually requires around four weeks.

Treatment for the fractures just discussed appears to be almost casual. The following types of pelvic fracture, however, require more strenuous treatment as well as a longer period of immobilization (that is, from six to eight weeks).

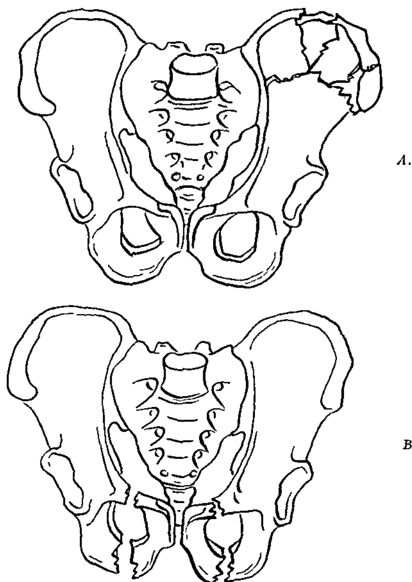


Fig 125.—*A*, Fracture of the iliac wing. *B*, Double vertical fracture of the pelvis.

Double Vertical Fractures of the Superior and Inferior Pubic Rami Bilaterally.—These really consist of four separate fractures occurring so that the symphysis pubis is free. (Fig. 125, *B*.) A pelvic sling is commonly used in treatment of such an injury to suspend the patient just above the bed. The sides of the sling are arranged so that no undue medial compression is exerted on the pelvis.

Malgaigne's Fracture.—This is a double vertical fracture of the pubic rami on one side associated with a dislocation or fracture-dislocation of the sacro-

iliac joint on the same side. Under such circumstances, it is apparent that the entire hindquarter moves freely upward and rotates externally. The leg is shortened as a consequence. In treatment, a force to pull the entire quarter downward and a force to rotate the free portion of the pelvis internally are necessary. These two forces are supplied by traction on the leg and by a pelvic sling. The sides of the sling are regulated so as to exert a considerable force toward the midline.

Separation of the Symphysis Pubis and Dislocation of the Sacroiliac joint.—These frequently occur together and are treated by a pelvic sling and by traction on the leg on the involved side, the same as Malgaigne's fracture. Some treat the dislocation by manipulation, consisting of traction, internal rotation, and abduction of the involved extermity, and then apply a snug hip spica cast. Others place the patient on the involved side, allowing the patient's weight to effect the reduction, and apply a snug hip spica cast with the patient still in a lateral recumbency. There is rarely, if ever, an indication for open reduction in the treatment of fractures of the pelvis.

Aftertreatment.—The aftertreatment of a pelvic fracture is important. It is well not to attempt ambulation too early. In the more serious fractures, treatment in bed is continued for six to eight weeks. Gradual weight-bearing is then started. If the patient experiences pain upon attempting to walk, it is better to restrict activities for a week or so longer than to hurry the patient. Chronic and disabling pain may result from efforts to make the patient ambulatory too soon.

Serious late complications include pain in the low back, shortening of the leg due to malunion, malunion leading to cephalopelvic disproportion in a woman of childbearing age, and certain residual effects of the injury to the genitourinary system.

In filling out an insurance form the practitioner should estimate that the *patient will be totally disabled for twelve to fourteen weeks and partially disabled for an additional four to six weeks.* Under "Anticipated Loss" he may note that there may be pain in the back upon weight-bearing.

Compression Fracture

If the patient complains of pain in the back due to injury and if the practitioner suspects a compression fracture simply from the severity and type of injury, the examination of the patient is more limited than in those with injuries of lesser magnitude. That is, the patient is not asked to stand erect and do forward and side-to-side bending, etc. However, with the patient on his side, palpation can be carried out and areas of tenderness and the presence of muscle spasm noted. It is also possible to carry out the straight leg raising tests and to test the reflexes, the sensation, and muscle power of the lower extremities; these tests are essential to determine whether or not there is impingement on the nerves.

A compression fracture is sustained through forcible flexion to the vertebral column. For example, a patient who falls a considerable height and lands on either the feet or the buttocks suffers a flexion injury to the spine which

may cause a compression fracture of the spine. This fracture occurs in the centrum of the vertebral body, on the anterosuperior portion of the vertebral body. Characteristically (as seen on the lateral roentgenograms) a *triangular-shaped* fragment is broken off from the vertebral body and is forced downward and anteriorly. (Fig. 126.) The remainder of the anterior surface of the vertebra may be buckled. It is clear that the height of the vertebral centrum is diminished, especially at its anterior margin. Hence, the vertebra becomes wedged. Note that if the *inferior* surface of a vertebra is also wedged, it should be ascertained that some condition other than a fracture is not present. The anterosuperior portion is predominantly the site of fracture. If both the anterosuperior and the anteroinferior aspects of a given vertebra are wedged, the condition may be residual deformity of some previous disease (see Fig. 45), such as osteochondritis,

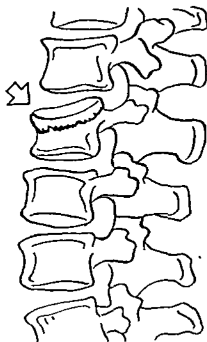


Fig. 126 —Compression fracture of a vertebral body. Note that it is the anterosuperior portion of the body which is involved and that the inferior aspect is intact.

rather than a fracture. The vertebral column angulates at the site of a compression fracture, and the spinous process appears more prominent than normal (gibbus formation) at the site of the injury.

The lumbar spine is the most common location of a compression fracture. Contrary to popular belief, spinal cord injury is not commonly associated with the usual compression fracture in the dorsal and lumbar spines. If there is a dislocation or a fracture of the posterior arch in addition to the compression fracture, then spinal cord injury, with paralysis or other neurologic signs, is common. Many times, a patient with a compression fracture complains of transient root pain which is not usually serious.

The clinical signs of a compression fracture of the lumbar spine are as follows. The patient prefers to lie on his side, with the thighs flexed on the abdomen.

Inspection may reveal a small gibbus. There is a sharply localized exquisite tenderness to percussion over the spinous process of the affected vertebra. Spasm of the erector spinae muscle may be present, and there is a large area of tenderness to percussion surrounding the affected vertebra (as distinct from the sharply localized and more severe tenderness over the involved spinous process). Straight leg raising is markedly limited on each side and is accompanied by severe pain in the low back. The reflexes in the knees and ankles are normal, equal, and active. There are no abnormal sensory findings in either lower extremity. Special care is taken to repeatedly test the reflexes and sensation during the ensuing treatment in order to discover any signs of spinal cord compression, even though cord compression is not common in the usual compression fracture of the lumbar spine. The mucle power of both lower extremities is checked routinely for the same reason.

It is in order to say a word regarding the emergency treatment of a patient suspected of having a compression fracture who is first seen at the site of the accident. The danger in this circumstance is transporting the patient to a hospital. If a patient has a compression fracture of the spine, flexion of the spine only increases the injury and can endanger the spinal cord. Therefore, it is unwise to carry such a patient back down in a resilient support, such as a blanket, because flexion of the spine can occur. The patient should be carried supine on a rigid support, such as a wide board, not on a yielding support.

One type of treatment is directed at restoring the vertical diameter of the compressed vertebra. This is achieved by placing the spine in hyperextension (the reverse of the force causing the fracture), using the important and exceedingly strong anterior longitudinal ligament. This ligament runs along the anterior surfaces of the vertebrae. During hyperextension, the ligament becomes taut and helps mold the depressed and anteriorly situated fragment backward and upward to reconstitute the normal height of the vertebral body. Often, the patient cannot tolerate the position of hyperextension unless it has been achieved slowly over a period of seven to ten days. Slow hyperextension is accomplished by gradually raising the gatch of a hospital bed while the patient lies supine over it. The patient's head is placed at the foot of the bed to make use of the gatch. When it appears that the patient can tolerate the position of correction, he is placed prone in a canvas sling. The sling is slackened until the back is well arched maximally at the level of the fracture. A body cast is then applied. It extends from the symphysis pubis to the sternoclavicular joints in order to maintain an adequate hyperextension of the spine.

Some orthopedists allow the patient to be ambulatory while wearing the plaster jacket. We prefer to keep the patient at bed rest for as long as the cast remains on, which is twelve weeks. After removal of the cast, a Taylor back brace is applied and is worn for an additional nine months. The need to protect the back for such an apparently long time is explained in the following discussion of the late complications of a compression fracture.

Complications are divided into the immediate and the late. A patient with a fresh compression fracture is especially prone to develop urinary retention and/or adynamic intestinal ileus. These conditions are controlled by the usual con-

servative treatments, such as the use of stupes, the administration of Prostigmin, the insertion of rectal tubes, etc. The complication of paralysis is more likely to occur when there is an associated significant dislocation or a severe fracture of the posterior arch. If paralysis does occur, it is managed in cooperation with the neurosurgeon, who may elect a procedure such as decompression by laminectomy.

The most serious late complication is Kümmell's disease, which is manifest by rarefaction and collapse of the vertebral body, sometimes as late as a year or two after the fracture. The nature of Kümmell's disease is not entirely clear. Some believe that the process is actually a nonunion of the various fractured fragments. Others believe that the process is posttraumatic rarefactive collapse of the vertebra. *In any event, deformity and pain are responsible for the subsequent disability.*

Localized hypertrophic arthritis may develop prematurely at the site of a previous compression fracture and cause a prolonged and, at times, disabling pain. It is usually associated with instability at the disc level above or below the fracture. At times the pain is amenable to the usual conservative measures. If not, spinal fusion is performed.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for six to nine months and partially disabled for an additional one to three months. Under "Anticipated Loss" he should note that there may be pain when heavy objects are lifted.

Pathologic Compression Fracture.—Pathologic fractures occur in numerous places in the body, but a favorite site is the vertebral column. A pathologic compression fracture of the spine can be due to several conditions. Some of these fundamental conditions are primary tumor, such as multiple myeloma; metastatic tumor, such as carcinoma of the breast; senile osteoporosis; osteoporosis due to chronic acidosis (that is, renal failure); osteoporosis due to alimentary causes (for example, malnutrition), osteoporosis due to hypoparathyroidism, etc.

Pathologic fracutres occur from much less trauma than the ordinary compression fractures require. Often back pain is the only complaint, and diagnosis is made only by roentgenographic examination. Treatment varies, of course, with the fundamental disease, but a support for the back is used in all patients.

Fracture of the Transverse Processes

The transverse processes of the lumbar spine are particularly likely to be fractured as a result of direct violence to the back. (Fig. 127.) Many times the displacement is slight if, indeed, any is present. It is also possible to sustain this fracture in an indirect manner through the force of muscle pull which, in essence, avulses the transverse process. Usually the only complaint is of back pain.

Tenderness is elicted 2 to 4 cm. laterally from the midline, and spasm of the erector spinae muscles is present. Fracture of the transverse processes is minor in comparison with a compression fracture of the spine. Ordinarily, bed rest for two to three weeks on a bedboard and a firm mattress, supplemented by the local application of heat, is sufficient treatment to overcome the acute pain. Also the administration of mephenesin, 1 Gm. three times a day for three to four

days, will aid in relaxing the muscle spasm and giving relief from pain. Muscle spasm is unusually prominent in a fracture of the transverse processes of the lumbar vertebra. It prolongs the disability and the pain for what seems to be an undue length of time. A canvas belt to support the region is worn for a few months, until the local tenderness and the occasional twinges of pain disappear.

A warning against undertreatment of a fracture of the transverse processes should be heeded. Some make light of the condition and make the patient ambulatory immediately, without using support for the back, or a firm mattress on the bed and with very little treatment other than the application of heat. It is true that the patient should be reassured that his injury is definitely not a "broken back" and that he most likely will recover fully within a very few weeks. However, if adequate treatment is not given, the patient will have pain and disability for a much longer time than is otherwise necessary.

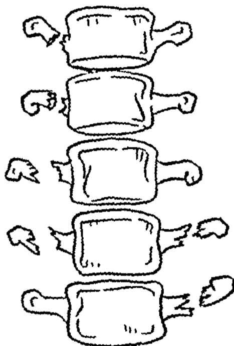


Fig. 127.—Fractures of several transverse processes of the lumbar spine.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for six to eight weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he should note that there will be none.

Strain of the Muscles, Ligaments, and Joints of the Low Back

We believe that the diagnosis of acute strain of a sacroiliac joint should rarely, if ever, be made. The reason for this is that the sacroiliac joints are exceedingly strong and stable articulations bound together by uncommonly powerful ligaments, and the joint surfaces are fashioned so that a great deal of stability results from the joint surfaces themselves. Consequently, it requires

a trauma of exceptional severity to truly injure the sacroiliac joints. Therefore in acute injury of the low back, diagnostic thinking should be directed toward stress, strain, and injury to the muscles and ligaments and the intervertebral disc in the area from L-5 to S-1; that is, the lumbosacral joint rather than toward strain of the sacroiliac joints. Furthermore, we believe that it is simply begging the question to attempt to divide the injury into acute strain of the muscles of the low back, acute strain of the ligaments of the low back, or acute strain of the lumbosacral joint. All of these terms purport to specify various subdivisions in acute or chronic strain of the back. Actually, they seem to impede diagnosis and treatment. We feel that nothing is gained by making such a division anymore than is gained by such a division in an analogous situation elsewhere in the body. In our simplification of injury to the low back, diagnosis is limited on one hand to acute strain of the muscles or ligaments surrounding the lumbosacral joint and on the other to a more deep-seated and extensive injury, such as damage to the intervertebral disc (which, of course, postulates a certain degree of strain and stress on the muscles and ligaments in that area). In essence, the simple and easy way to proceed is to consider whether the injury is likely to cause a fracture of some type and, if so, whether the x-ray pictures are positive. If there is no fracture, and if the history of the injury is consistent with the roentgenograms, then the injury is either acute strain of the muscles and ligaments of the low back or a deep-seated disturbance of the intervertebral disc

We will first discuss the acute injury (those cases seen either the day of the injury or within three or four days after the traumatic episode), and then discuss the conditions which persist after the acute pain and injury have apparently subsided (those cases first seen one, two, or more weeks after the original traumatic episode).

Acute Strain.—The usual history in the acute strain of the muscles and ligaments of the low back is that the patient, a young adult male, felt a knife-like pain in the low back, frequently accompanied by a snapping sound, while lifting a heavy object. The patient is ordinarily unable to continue his work because of the severe pain. This complaint of low back pain is not accompanied by sciatic pain in the leg.

With the patient erect, examination reveals that C-7 is not displaced from the midline, and there is no shift of the shoulders to either side. Tenderness to palpation is elicited over the sacrum at the insertions of the erector spinae muscles and somewhat upward to the level of L-5 to L-4. The tenderness is unilateral when the injury mainly affects one side or bilateral when the injury is more severe. At times, only muscle tenderness is present, and there is no tenderness overlying the interspinous ligaments. However, it is not unusual to find that, in addition to tenderness overlying the insertions of the muscles, the interspinous ligaments of the low back, particularly L-4 to L-5 or L-5 to S-1, reveal tenderness to pressure. With the patient erect, forward flexion is likely to be arrested at about 30 to 40 degrees and there is pain and accompanying muscle spasm in the low back. The muscle spasm is palpable as a sudden tightening of the erector spinae muscles or, in a thin patient, is apparent on inspection. Extension of the back from the upright position frequently does not cause pain. If the erector

spinae muscle on the left is strained, then left lateral bending is not painful, but right lateral bending is. The reverse occurs in muscle strain of the low back on the right side. Side-to-side bending is restricted on both the right and the left, or course, if the erector spinae muscles on both sides are strained. Rotation to the right and to the left ordinarily is not particularly painful. With the patient supine, straight leg raising is limited on one or both sides, depending upon whether there is a unilateral or bilateral strain. The limitation on one side is likely to be different from that on the other side. The straight leg raising is likely to be limited to around 45 degrees. The lumbosacral maneuver of forced flexion of the thigh on the abdomen, with the knees flexed, is likely to produce pain. The knee and ankle jerks are normal. Sensory examination of the dorsum of the feet and the lateral aspect of the lower leg, particularly behind the fibula, reveals normal sensitivity to pinprick. The power of the extensor *hallucis longus* of the great toe is normal. The roentgenograms show a normal condition or, at the most, a loss of the normal lumbar lordosis. Loss of normal lumbar lordosis under these circumstances is an indication of muscle spasm, which in turn is an indication of acute ligamentous or muscle strain.

Acute muscle and ligamentous strain of the low back can be distinguished from other conditions due to injury as follows: (1) It is distinguished from a compression fracture by a history of lesser violence than occurs in one of the characteristic circumstances described previously under Compression Fracture. Also, in acute strain there is muscle and ligamentous tenderness, only, while in a compression fracture there are muscle and ligamentous tenderness and tenderness directly over the spinous process of the involved vertebra, which is more acute than the muscle tenderness. Furthermore, a gibbus is sometimes present in a compression fracture, but not in acute strain. In a compression fracture, the patient prefers to lie on his side with his legs drawn up in flexion at the hips and at the knees The roentgenogram, of course, is the surest and simplest means of distinguishing between an acute strain and a compression fracture. (2) It is differentiated from a ruptured intervertebral disc, even in the absence of sciatic pain, by the fact that in an acute strain the knee and ankle jerks are normal, whereas in a ruptured intervertebral disk there is a diminution of the ankle jerk or the knee jerk (or both). Also, in acute strain there is no alteration in the sensitivity to pinprick over the dorsum of the foot, and no decrease in active extension of the great toe, as usually occurs in a ruptured intervertebral disc. Furthermore in an acute strain, lateral flexion toward the side of injury is not likely to be painful, while the same movement in a ruptured intervertebral disc is likely to produce pain Also, there is no spastic scoliosis displacing C-7 laterally from the midline (a visible shift of the shoulders in relation to the pelvis) in an acute strain, as very commonly occurs in a ruptured intervertebral disc. (3) It is distinguished from an acute facet syndrome by the absence of a shift of the shoulders to one side or the other, resulting in a spastic type of scoliosis (list). Lateral bending in both directions may be painful and limited in an acute strain, while in an acute facet syndrome, lateral bending to the same side to which the shoulders have shifted is not limited nor painful, but lateral bending to the side opposite that to which the shoulders have shifted may be practically impossible due to

pain and spasm. (4) It is distinguished from coccygodynia in several ways. One is that the history in an acute strain is of a lifting movement, while in coccygodynia it is likely to be a fall directly on the buttocks. Furthermore, in an acute muscle strain, the tenderness overlies the sacrum and low back, whereas in coccygodynia the tenderness and pain are sharply localized in the coccyx. In coccygodynia forward flexion may produce pain, but ordinarily the range is not limited, while in acute strain forward flexion is likely to be arrested at about 30 to 40 degrees, accompanied by pain. Lateral bending in acute strain is limited and painful, whereas in coccygodynia it is neither painful nor limited. The roentgenograms in coccygodynia are of course negative.

The principles of treatment of acute strain of the muscles and ligaments of the low back are the same as those used in muscle and ligamentous strain anywhere else in the body. They consist of rest of and the avoidance of stress on the injured tissues. Ligamentous tissue requires three weeks to heal. Bed rest, with medication to relieve pain, is carried out. Heat may be applied intermittently, and mephenesin may be given to relax muscle spasm. The duration of the bed rest depends somewhat upon the physician's judgment of the severity of the original injury, but ordinarily ten days to two weeks usually suffice. When the patient is first allowed up, a support for the low back, consisting of a canvas belt with metal reinforcements, is worn. Such a support serves as a reminder to the patient not to engage in heavy lifting nor to repeatedly bend the back and also limits the motion of the low back. The support is worn for approximately one month, after which it is worn for increasingly shorter periods each day. It is removed for a given length of time at the start of the program, and the length of time during which the support remains off is increased each day until the patient is weaned from it. At times, particularly if adequate treatment was not instituted in the beginning, chronic pain and muscle spasm may ensue after the acute pain subsides. Novocain injected intramuscularly, particularly in "trigger-spot" areas, has proved of value in controlling pain following acute strain.

In acute muscle and ligamentous strain of the low back, the total disability usually extends from two to four weeks, followed by a period of partial disability for four additional weeks, and during this time repeated bending and the lifting of heavy objects is avoided. If the complaint of pain in the low back continues without much change from the acute phase, the patient should be examined repeatedly, particularly to test sensation in both lower extremities and the condition of the reflexes (especially ankle jerk), with the thought in mind that the patient may have sustained a ruptured intervertebral disc. Consultation should be obtained if the acute strain does not appear to be subsiding satisfactorily.

Thus far we have considered acute strain of the muscles and ligaments of the low back in a mechanically normal back before injury was sustained. However, sometimes the low back is mechanically abnormal before acute injury occurs. These mechanical abnormalities, of course, become apparent when the roentgenograms are made and include such conditions as spondylolisthesis, an anomaly of L-5 such as a partial sacralization, abnormally directed zygapophyseal joints (facets), and hypertrophic changes It is *curious* that a person with a mechanically abnormal back may live several years without experiencing difficulty

until an injury is superimposed upon the abnormality. Under these circumstances the patient complains of pain for a much more prolonged period than does the patient with a mechanically normal back with the same type of injury. Furthermore, a permanent partial disability may be sustained. Strain superimposed on an abnormal back may produce sciatic pain as well, but often the complaint is simply of back pain without sciatica. Clinically, back strain superimposed upon the abnormal back is essentially the same as acute strain of the muscles and ligaments of the low back, with the exception of the roentgenograms, which reveal the fundamental changes in the mechanical structure. The patient is ordinarily a young, active male (except when hypertrophic changes are the underlying abnormality) who lifts something heavy at work, with a subsequent onset of back pain. Examination reveals that C-7 is not displaced from the midline and that there is tenderness overlying the erector spinae muscles, usually on both sides over the sacrum and extending somewhat upward. There may be a certain rather low-grade tenderness overlying the interspinous ligaments. With the patient erect, forward flexion is limited. Lateral bending from side to side is likely to be limited and accompanied by pain. Rotation to the right and to the left ordinarily is carried out well. With the patient supine, straight leg raising is limited, usually more on one side than on the other. The lumbosacral sign is likely to be positive. The legs reveal no change in the reflexes or sensation, and the extensor hallucis longus tests are normal. The roentgenograms are the surest means of confirming an abnormal back in acute strain of the muscles and ligaments because they show evidences of spondylolisthesis, sacralization of L-5, abnormally directed facets, or hypertrophic changes. The roentgenograms likewise distinguish the condition from a compression fracture. The diagnosis of strain superimposed upon an abnormality is distinguished from a ruptured intervertebral disc and an acute facet syndrome by the fact that the shoulders are not shifted, by the fact that there are no reflex or sensory changes, and by myelography, if necessary.

Treatment of the condition is much the same as for strain of the ligaments or muscles of the low back, except that a more prolonged course is necessary. Bed rest is prescribed, and, if the condition is sufficiently severe, a low back cast may be applied to aid in immobilization of the low back. It may be necessary to carry out immobilization with a cast and bed rest for as long as four to six weeks. When the cast is removed and the patient is allowed up, a support to the low back is worn for four to eight additional weeks As the condition improves, the support is removed gradually. The practitioner is warned to constantly re-examine the patient for the presence of a rupture of the intervertebral disc, which might show up during the ensuing weeks of convalescence.

The possibility that such a patient may have a permanent partial disability, since he may never recover completely or be absolutely free from pain, should be anticipated. The prolonged symptoms and the possibility of a permanent partial disability may be due to the fact that the muscles and ligaments in an abnormal back prior to injury are strong enough to support the low back, but after injury they are weakened, resulting in a *permanently unstable* back subject to *constant pain*. (This is pursued further in the discussion of chronic strain even in a back apparently mechanically normal as seen on the roentgenograms.)

Chronic Strain.—A patient with a "normal" back who sustains an acute strain may pass from a condition of acute pain and disability to a chronic condition in which the complaint is of nagging, unrelenting, and sometimes disabling pain. We have a possible explanation for this phenomenon which might explain why both the abnormal and the normal back can progress to a chronic state instead of recovery after one single episode of acute trauma. Regardless of whether this thesis can be supported scientifically by adequate evidence, it is at least one way of looking at the problem. Naturally, those cases in which a long-standing complaint is probably made with the hope of financial gain through a legal settlement are excluded. In a back assumed to be normal which sustains a trauma severe enough to strain the ligaments and muscles of the low back, the muscles and ligaments, including the interspinous ligaments, the ligaments attaching the vertebral bodies to each other and to the sacrum, and the ligaments containing the nucleus pulposus, are stretched beyond their physiologic capacity. In addition, the intervertebral disc itself may be simultaneously subjected to injury, not necessarily severe enough that rupture will ensue, but severe enough that certain degenerative changes may occur within the disc, producing abnormal mobility of the disc. Hence it can be theorized that a normal back, having been strained severely enough, has gained considerable mobility in a manner and to a degree which are undesirable in this particular location, resulting in instability with attendant pain. In other words, the support of the vertebral column depends henceforth more on the power and integrity of the muscles than on the ligaments, as it had hitherto In essence, the strain produces an unstable back with great mobility because the ligaments are no longer able to give it the necessary support. This is also true of an injured, degenerative, and mobile intervertebral disc. If this concept is true, then persons with a recognized mechanical disorder of the back would be most likely to do poorly following strain. Since they do not have as much stability in the back as normal persons from the bony contours (for example, spondylolisthesis robs the vertebral centrum of the stability provided by the posterior bony arch and facets), they must depend even more upon the ligaments to provide stability. Thus if an abnormal back sustains ligamentous injury it is a matter of serious concern, since the only structures which provide stability and prevent pain have become lax and can no longer supply these vital services.

Consequently, in the treatment of both the so-called "normal" and "abnormal" back which has progressed to chronic pain following acute injury, the fundamental objective is to provide stability. Stability is often achieved by building up the power and capacity of the musculature surrounding the low back through a program of progressive resistive exercises in which gradually increased resistance is given to a specific muscle group. It is well to realize that the muscles to be strengthened not only include the erector spinae, but also those which flex the spine, those which lift the lower extremities (straight leg raising), the abdominal muscles, the flank muscles, etc. Stability is also achieved by the use of a support of some type. There is no doubt that a support helps to diminish pain. It should be noted that a support may increase muscle weakness and thereby increase low back instability, leaving the patient dependent upon the support for what relief he does get. If a support is used for a considerable length of time,

muscle stiffness, with its own attendant pain, may add to the original disability. Therefore, it is better that treatment be directed to conditioning of the muscles, *realizing that a support may be used for a short while only. If muscle-building does not effect relief, a spinal fusion should be considered and expert advice obtained.* In summary, a chronic strain of the low back is managed by a program of exercises, by the use of a firm mattress, by the wearing of a support if necessary (and then only temporarily), and by spinal fusion if expert advice indicates such is necessary.

Rupture of the Intervertebral Disc

Little if any mention has been made thus far of the complaint of sciatic pain. It is stressed that a patient may complain of pure and simple back pain, with no complaint of sciatic pain, and yet the fundamental cause of the back pain will be a rupture of the intervertebral disc. Emphasis is placed upon the fact that a complaint of sciatic pain (even in the absence of back pain) if it follows either recent or previous trauma should suggest a rupture of the intervertebral disc. It should be remembered, however, that a rupture of the intervertebral disc is *not the only* cause of sciatic pain (regardless of back pain or not). *In essence, the possibility of a rupture of the intervertebral disc must be considered in a patient who appears, on the surface, to have simply an acute or chronic strain of the muscles, ligaments, and joints of the low back. The diagnosis of a* ruptured intervertebral disc *must be considered* in any patient who has sciatic pain, even in the absence of back pain.

In our discussion we present first the history and findings in the condition of a ruptured intervertebral disc with back pain only, and second, the history and findings in the same condition with both back pain and sciatic pain.

With Back Pain Only.—It is well known that a ruptured intervertebral disc ordinarily produces not only back pain, but also sciatic pain. However, difficulty in diagnosis occurs because it is not necessary for a ruptured intervertebral disc to produce either pain in the sciatic distribution or significant findings in the lower extremity, such as diminution of sensation and alteration in the reflexes and the power of the extensor hallucis longus muscle. Therefore, when there are signs and symptoms in the low back, even in the absence of signs and symptoms in the lower extremities, the possibility of a ruptured intervertebral disc should be kept in mind. The clinical history and findings are quire the same as in an acute strain of the muscles, ligaments, and joints of the low back. The patient, who complains of back pain only, is ordinarily a young male engaged in active, strenuous labor who injures himself lifting a heavy object and is disabled because of back pain. Examination may reveal C-7 over the midline and tenderness in the muscles of the low back, together with tenderness in the interspinous ligaments. Forward flexion is limited and accompanied by muscle spasm, side-to-side bending is limited, and rotational movement may cause pain. With the patient supine, straight leg raising is limited, and the lumbosacral signs are positive. Abnormal neurologic signs in the leg are absent. If the diagnosis is *apparently* strain of the low back, but the strain does not respond to adequate *treatment,* consultation should be held to determine the possibility of a ruptured intervertebral disc. *The usual roentgenograms in these circumstances are of*

course negative. Short of actual surgical exploration, myelography is almost the only diagnostic procedure available for making a correct diagnosis.

With Back Pain and Sciatic Pain.—The complaint of back pain and sciatic pain following injury may stem from a great many causes in addition to a ruptured intervertebral disc. (Figs. 128 and 129.) Spondylolisthesis, hyper-

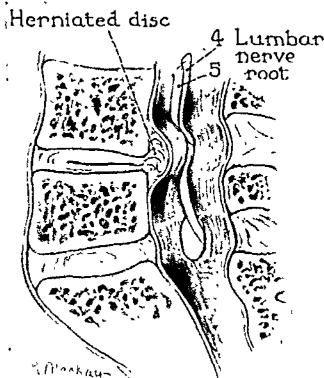


Fig. 128.—Schematic drawing of a herniated disc showing the manner in which the nerve roots are compressed, thus explaining the symptoms and the physical findings in the lower extremity which are present in sciatica (From Walker, E: South. Surgeon 9:820, 1940.)

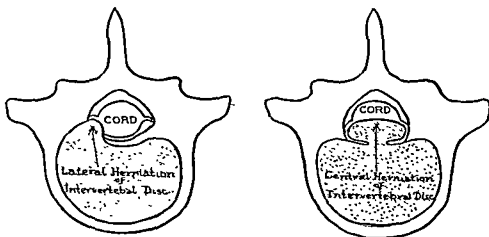


Fig. 129.—Ruptured disc. Diagrams show different positions of herniation. (From Larson, C. B., and Gould, M.. Calderwood's Orthopedic Nursing, 1957, The C. V. Mosby Co.)

trophic arthritis, and an acute facet syndrome ordinarily simply cause back pain, with or without injury, but upon occasion, these conditions cause sciatic pain as well and should be kept in mind as possible alternative diagnoses.

Any one of several histories can be obtained when a rupture of the intervertebral disc occurs. The first is that the patient, a young, adult male actively engaged in strenuous labor notes a sudden, severe back pain while lifting a heavy object. There may be no sciatic pain at this time. The severity of pain may be such that the patient is forced to stop his work and return home. Within twenty-four hours he may note the onset of sciatic pain which he describes as starting in the buttocks, usually on one side, extending down the posterior aspect of the involved thigh to the knee, and traveling along the lateral aspect of the lower leg to just behind the fibula and even into the foot. A second type of history is that a person sustains an injury at work which is followed by back pain but no leg pain. The patient may be treated on the assumption that he is suffering from a back strain and in two to three weeks may feel sufficiently recovered to return to work. He may then note recurrent episodes of back pain over a period of several months and never have complete relief from pain in the interim between exacerbations. Then suddenly, for no apparent reason or for an apparently inadequate reason, the patient notes the onset not only of back pain, but also of sciatic pain. A third history is that the patient sustains an injury due to lifting a heavy object, followed by back pain for a short period of one to two weeks, without sciatic pain. He may note the onset of sciatic pain at a later date and surprisingly enough does not complain of back pain at that time.

Any one of the three histories just described should suggest a ruptured intervertebral disc, and examination should be carried out with such a possibility distinctly in mind. The clinical examination may reveal that C-7 has shifted laterally from the midline and that the shoulders have shifted in relation to the pelvis. If the patient has a history of an injury, if he complains of sciatic pain, and if there is a shift of the shoulders, the practitioner should suspect all the more that the diagnosis is a ruptured intervertebral disc. On palpation the low back may reveal rather sharply localized tenderness overlying the interspinous ligaments of L-5 to S-1 or L-4 to L-5, depending upon which of the two sites actually has the ruptured disc. Tenderness in the erector spinae muscles on either side of the midline, although possibly present, is not so prominent a feature as tenderness directly in the midline. Frequently, there is a point of especially marked tenderness just lateral to the erector spinae mass on the side of the sciatic complaint. Furthermore, it is often possible to find tenderness directly overlying the sciatic nerve, high on the posterior aspect of the thigh and just below the fold of the buttock. Upon occasion there will also be a mild degree of tenderness, but nonetheless definite, overlying the path of the sciatic nerve on the posterior aspect of the thigh and extending almost to knee-joint level. With the patient erect, forward flexion is likely to be markedly limited so that the patient can bend forward though an arc of only 25 to 30 degrees. Pain increases in the posterior aspect of the thigh, and an attendant muscle spasm of the low back is observed. Lateral bending toward the side of the sciatic pain is likely to be more painful than lateral bending away from the side of the sciatic pain. Rotation to the right and left is ordinarily well carried out, without

particular pain. With the patient supine, straight leg raising on the unaffected side is frequently normal or almost normal, while on the affected side it is markedly limited. If the thigh and leg are flexed on the abdomen (that is, with both knee and thigh flexed) and pressure exerted, pain is likely to occur in the lumbosacral region of the low back. The ankle jerk on the affected side is very likely to be diminished or absent. At times, however, the ankle jerk is normal and the knee jerk is diminished. It is particularly important to test the power of the extensor hallucis longus, since this muscle very often will show a marked weakness on the affected side in comparison with the unaffected side. At times, if the condition is severe, dorsiflexion and eversion of the foot at the ankle may be sufficiently weakened as to produce an almost genuine foot-drop deformity. Sensation on the dorsum of the affected foot is compared with the other, and a diminution in



Fig 130 —Ruptured nucleus pulposus protruding into a column of radiopaque contrast media during myelography.

the sensitivity to pinprick in theaffected foot is frequently present posterior to the lateral malleolus of the ankle. These clinical findings, together with the proper history, indicate a presumptive diagnosis of a rupture of the intervertebral disc. Roentgenograms of the lumbosacral region are usually negative. Infrequently, a narrowing between L-5 and S-1 or L-4 and L-5 may be noted. If this is present, the presumption that the diagnosis is a ruptured intervertebral disc is strengthened. The best proof of the diagnosis lies in a *positive* myelogram. (Fig. 130.) The practitioner is cautioned against relying too much on the myelogram, since it may fail to reveal a rupture of the intervertebral disc which later surgical exploration discloses. Conversely, at times the myelogram appears to show a ruptured intervertebral disc when none, in truth, exists We believe that it is not necessary to obtain a myelogram in every instance in which the presumptive diagnosis is a ruptured intervertebral disc. (The reason for this will become more apparent when treatment is discussed.) We are of the opinion that a myelogram is of particular benefit if the patient is likely to be involved in a

medicolegal dispute. If surgery is contemplated, myelography should, of course, be carried out before surgery is performed. If there is the possibility of a spinal cord tumor in the differential diagnosis, myelography is definitely indicated.

A rupture of the intervertebral disc should be distinguished from spondylolisthesis which also produces back pain and sciatic pain upon occasion. As in a ruptured intervertebral disc, a patient who has spondylolisthesis may injure his back and complain not only of back pain, but also of sciatic pain. Examination is likely to show the signs of a disturbance in the low back, but there is usually a lack of neurologic changes in the lower extremities, such as diminution in sensitivity to pinprick, weakness of the extensor hallucis longus, and changes in the reflexes of the ankles or knees, as is common in a ruptured intervertebral disc. The x-ray pictures of course reveal the presence of spondylolisthesis. It should be kept in mind, however, that it is quite possible to rupture an intervertebral disc at the site of the spondylolisthesis. Therefore, if a patient presents with neurologic changes in the lower extremities consistent with a ruptured intervertebral disc, a myelogram should be obtained.

A ruptured intervertebral disc should be distinguished from an injury to the back in which the patient complains of back pain and sciatic pain but who has rather marked hypertrophic changes as shown on the x-ray pictures. In such a condition a sciatic radiculitis may occur as a result of nerve root compression within the foramen. Examination reveals evidences of back strain and limitation of motion due to hypertrophic arthritis, but the neurologic signs in the lower extremities characteritic of a ruptured intervertebral disc most likely are absent.

It may be extremely difficult to distinguish between a ruptured intervertebral disc and an acute facet syndrome inasmuch as there are back pain and sciatic pain and probably a shift of the shoulders in relation to the pelvis in both conditions. In the early stages of a ruptured intervertebral disc, when neurologic findings in the lower extremities may well be absent, it is often impossible to distinguish it clinically from acute facet syndrome. However, if neurologic changes in the lower extremities are present, the presumptive diagnosis is a ruptured intervertebral disc. The subsequent course will distinguish between the two.

In the treatment of a ruptured intervertebral disc, the practitioner has certain facts to consider. In the usual case, provided that it is the first episode, conservative therapy should be given a thorough trial. The patient is placed at bed rest, using a firm mattress supported by a bedboard. Medication to relieve pain and mephenesin, 3 Gm. daily, to combat muscle spasm may make the patient more comfortable. In addition, skin traction is often applied to the affected leg. The rationale for this is simply to immobilze the leg rather than the possible distraction of the two vertebral bodies. If the affected leg remains quiet, relief of pain may be hastened since the nerve roots are not so likely to be tightened repeatedly across the ruptured disc. Sometimes, if the condition is somewhat more severe than average, the application of a plaster cast to the low back, combined with bed rest, is successful. The patient should be kept at bed rest between four to six weeks or a minimum of three weeks At the end of this time, provided that satisfactory progress has been made, he is allowed up, and

a support to the low back is applied. He should not be allowed to bend repeatedly or lift heavy objects for an additional six weeks. It should be clear that there is no immediate need for obtaining a myelogram. As has been stated, if there is a medicolegal complication, a myelogram may very well be advisable, but from a purely medical standpoint, if surgery is not contemplated, a myelogram is of aid only if diagnosis is in doubt. If, the patient does not improve progressively while at bed rest, then surgery should be considered. Furthermore, it must be emphasized that if there is a progression of the neurologic signs, operative intervention should be undertaken. If, instead of a "first-offender" attack, it is a recurrent episode and the patient is becoming progressively disabled and unable to work, then surgery should be undertaken.

In summary, in the average case of ruptured intervertebral disc, conservative therapy is superior. It consists of bed rest with or without traction or bed rest with or without the application of a plaster cast for four to six weeks. This is followed by a gradual increase in activity while the back is supported by either a canvas support or a metal brace. If, however, the condition does not improve as expected, if the neurologic signs progress, or if the condition is recurrent, resulting in progressive disability, then surgery should be performed. Certainly before surgery is undertaken a myelogram should be obtained, not only to establish the diagnosis, but also to localize the lesion exactly. Some believe that, as a routine procedure, the area should be fused by a bone graft. Others believe that fusion should be done only if marked instability can be demonstrated by mobility in the affected spinous process. Many times surgery gives dramatic relief from back pain and sciatic pain, but it should be kept in mind that there may be a permanent partial loss of function, inasmuch as a recurrence of back pain and sciatic pain may result if the underlying instability does not heal. It should also be remembered that the same limitations can apply to the patient who has not had surgery. That is, a patient with a ruptured disc, whether conservatively or radically managed, is ill advised to bend repeatedly or lift heavy objects. Therefore, as a measure to prevent a permanent partial loss of function, surgery does not offer any more than does conservative therapy.

Acute Facet Syndrome

Sometimes a patient may complain of back pain due to an injury which appears to be minor. He bends over, about to lift an object, and twists his back in an awkward position, suffering an immediate disabling pain in the back, without ever having *lifted* the object. The history is of pain caused by an unnatural position rather than by actual stress and strain. It is also true that if a heavy object is lifted in a twisted or awkward position, the same fundamental disturbance may result. The patient complains of back pain or back pain plus the fact that he seems to walk sideways in a crablike gait. He is usually a young, adult male in whom it can be seen at a glance that the shoulders are shifted laterally in relation to the pelvis. That is, in appearance the patient has a scoliosis (list). Examination reveals that C-7 is shifted laterally by as much as one to two inches from the midline of the buttocks. The iliac crest on the side opposite the shift of C-7 appears to be higher than normal, and one leg appears almost as

if it were longer than the other. Tenderness is present in the low back, to the the side of the midline, and on the same side as the shift of C-7. If forward flexion is carried out, range is limited and also asymmetrical, so that a part of the chest on one side may protrude posteriorly more than on the opposite side. In other words, although the patient bends forward and although the motion is limited, the spine is still held in the position of scoliosis.

With the patient erect, side-to-side bending produces the following reactions. Lateral bending to the same side to which C-7 is shifted is normal and causes no complaint. Lateral bending to the side opposite to which C-7 is shifted is markedly limited, may be impossible to perform, and is a cause for complaint. Rotation to the side to which C-7 is displaced usually can be carried out, whereas rotation to the opposite side is markedly limited. With the patient supine, straight leg raising is limited, more particularly on the side to which C-7 is displaced. The lumbosacral sign may or may not be a cause of complaint. Sensation in both lower extremities is normal. The reflexes are normal, equal, and active, and there is no change in the power of the extensor hallucis longus on either side.

Acute facet syndrome is distinguished from a whole group of injuries of the low back by the shift of the shoulders and the asymmetrical pattern of the limitation of motion. This also distinguishes it from acute strain of the muscles, ligaments, and joints of the low back. It is distinguished from an acute strain superimposed upon the abnormal back and from a compression fracture by their characteristic appearance on the roentgenograms. It is distinguished from coccygodynia by the shift of the shoulders and by the fact that the tenderness does not overlie the coccyx. Roentgenograms in an acute facet syndrome sometimes reveal a scoliosis, but ordinarily they do not. The scoliosis (list) is sufficient to be apparent clinically without roentgenograms. A warning is given with regard to differentiation between an acute facet syndrome and a ruptured intervertebral disc, inasmuch as patients with either condition may present with the same history, and examination may reveal the same findings. The shoulders may be shifted in both conditions. The fact that the reflexes, sensation, and power of the extensor hallucis longus may be normal in the acute facet syndrome would ordinarily distinguish it from a ruptured intervertebral disc, but these findings are no help in the condition of a ruptured intervertebral disc with an absence of leg signs. Consequently, it may be impossible at first to distinguish between an acute facet syndrome and a ruptured intervertebral disc if a myelogram is not obtained.

Bed rest with traction on the legs is an acceptable conservative method of treatment. The application of a low back cast and the restriction of activities are likewise acceptable treatment A very simple and practical way to afford relief is to exert traction on the low back, without bed rest and mechanical appliances This is accomplished by instructing the patient to hang from an overhead beam by his arms while the low back and legs dangle limply. Repetition of this maneuver frequently during the day often controls most of the pain and the spastic scoliotic deformity as well within one to two days. A patient who has once shown evidence of an acute facet syndrome should be warned that the condition is likely to recur, particularly if he repeatedly twists the back in an awkward or abnormal position or in a position of forward flexion. Aids in the

treatment of an acute facet syndrome are the application of heat to the low back, the administration of mephenesin, 3.0 Gm. daily, the application of temporary support, such as a canvas belt, and the administration of medication to relieve the pain.

Coccygodynia

Although the patient complains of back pain, without sciatica, following injury, the mechanism of the injury in coccygodynia is usually characteristic enough to suggest the correct diagnosis to the practitioner. The patient, frequently a woman, slips on a stairway and falls directly on the buttocks. Examination reveals tenderness directly over the coccyx, with some slight extension of the tenderness up over the body of the sacrum. However, there is no tenderness at the lumbosacral joint or in the muscles of the low back. The range of motion is not limited, although there may be some pain during extreme forward flexion. The range of side-to-side bending and rotation is normal. The straight leg raising and lumbosacral signs are normal. The reflexes are normal, equal, and active. There are no abnormal sensory findings, and the power of the extensor hallucis longus muscle is normal. The roentgenograms are also normal. Therefore, the diagnosis depends upon the specific and exact location of tenderness over the coccyx following an injury of the type just described (a direct fall upon the buttocks), upon negative signs of disturbances of the low back per se, and upon negative findings on the roentgenograms.

Treatment may prove exceedingly difficult. In general, the condition is usually amenable to repeated applications of diathermy directly over the coccyx. We believe that the pain in acute coccygodynia should be brought under control with twelve to fourteen applications of diathermy. If diathermy does not relieve the condition, consultation should be held to study complicating factors. If diathermy does not bring the coccygodynia under control, Novocain is injected into the coccyx and surrounding tissue. In addition, the patient is advised to sit erectly upon a firm or hard chair so that the weight is borne on the ischial tuberosities and the coccyx itself is protected. The patient also should take frequent hot sitz baths, and avoid sitting on overstuffed furniture or theater seats and riding in an automobile. In these latter activities the weight is borne on the coccyx, with consequent irritation of the process and an increase in the pain. As a last resort it is possible to excise the coccyx if pain cannot be controlled in any other manner. However, excision of the coccyx does not always relieve the pain. Frequently, patients with coccygodynia have a great tendency to be neurotic.

NONTRAUMATIC DISORDERS OF THE BACK

Complaint	Likely Diagnoses	Page
Spontaneous back pain, with or without sciatica	(1) Unstable low back due to	262
	(a) Spondylolisthesis	262
	(b) Anomalous L-5	265
	(c) Abnormally directed facets	266
	(d) Lax ligaments	267

(Continued on following page)

arch and in the formation of the zygapophyseal joints so that a part of the zygapophyseal joint, as well as part of the pedicle or lamina, may be absent. In other words, it is much as if the facets were lacking, and as a result the entire vertebral column, which cannot be stabilized on the sacrum, slips forward. Furthermore, there is frequently a fibrocartilaginous mass of tissue surrounding the nerve root which exits in the foramina between L-5 and the sacrum. This explains why spondylolisthesis produces not only back pain, but also frequently radicular pain radiating into either the buttocks or the sciatic nerve distribution. The patient complains of a spontaneous low back pain, with or without pain in the buttocks, and with or without sciatic pain. The pain is likely to be intermittent, but its severity is likely to be more pressing and more disabling than back pain in a patient with an unstable low back due to lax ligaments or abnormal or anomalous L-5. The patient with spondoylolisthesis is likely to suffer exacerbations which are so acute as to be completely disabling, sometimes for a considerable period. As far as the general history and complaints are concerned, there is a very close similarity between spondylolisthesis and a ruptured intervertebral disc. Actually, it is quite possible that a rupture of the intervertebral disc has occurred in addition to the spondylolisthesis. Therefore, the complaint of *intermittent low back pain, with radiation to the buttocks and throughout* the sciatic nerve root distribution, should suggest the following likely diagnoses: (1) a ruptured intervertebral disc whose onset was not due to a specific trauma, (2) spondylolisthesis with nerve root pressure due to the fibrocartilaginous mass associated with the condition, or (3) spondylolisthesis *and* a ruptured intervertebral disc. With the patient erect, examination will probably reveal that C-7 is not displaced from the midline. Palpation of the low back sometimes reveals sufficient anterior displacement of the spinous process of L-4 or L-3 so that it is possible to make a clinical diagnosis. Usually, however, the physician is not sufficiently certain of the position of the spinous process of L-4 in relation to L-5 to be willing to make a tentative diagnosis of spondylolisthesis at this time. The interspinous ligament between L-5 and S-1 is likely to be tender. Forward flexion is likely to be limited by muscle spasm and associated with rather severe pain not only in the low back, but also in the sciatic distribution. Side-to-side bending may also be limited and painful. With the patient supine, straight leg raising upon the side affected by the sciatic pain is more limited than on the opposite side. The lumbosacral test will elicit rather marked pain. The reflexes in the ankle jerk may be diminished on the affected side, particularly if there is an associated ruptured intervertebral disc. Sensation may be dulled on the lateral border and dorsum of the foot on the affected side, and the extensor hallucis longus may be weak, particularly if there is an associated protrusion of the intervertebral disc. The x-ray pictures reveal the forward slipping of L-5 and the remainder of the vertebral column on the sacrum. (Fig. 131.) In some instances L-5 may be shifted forward by more than one half of its width. A defect or isthmus will be seen in the pedicle (for example, the zygapophyseal joint may have failed to form or has formed imperfectly), and spondyloschisis, a defect of the lamina, may be present.

Treatment of spondylolisthesis depends upon the severity of the pain, the degree of disability, the age of the patient, and whether or not there is an as-

Complaint	Likely Diagnoses	Page
Spontaneous back pain, with or without sciatica	(2) Strain due to obesity	268
	(3) Faulty posture (increased lumbar lordosis, increased dorsal kyphosis)	269
	(4) Hypertrophic change, with or without radiculitis	270
	(5) Osteomyelitis.	271
	(6) Tuberculosis.	272
	(7) Rheumatoid arthritis	273
	(8) Primary or metastatic tumor	275

We now consider those patients who complain of back pain or back pain and sciatica not due to injury but rather to a spontaneous condition which at first is mild and gradually increases in severity. Such a complaint suggests a fundamental mechanical instability in the low back due to any one of several possibilities, the presence of hypertrophic change, faulty posture, or strain due to obesity. In addition, such conditions as osteomyelitis, tuberculosis, rheumatoid arthritis, and primary or metastatic tumor must be considered. A simple way to make a tentative diagnosis is to decide whether the pain could reasonably be due to a mechanical disturbance or to a serious disease process. Actually, it is not so difficult to distinguish between these two large categories as it may seem at first. There are several factors which aid the practitioner in making the distinction. First, the pain is located, and its intensity (whether dull and nagging or sharp and shooting) is noted. In addition, it is established whether the pain is intermittent, coming in attacks, or constant and increasing. Second, the patient is questioned with regard to the mattress he uses, whether it is firm or soft, and asked whether he has worn or is wearing a support, either a boned undergarment or an elastic support. Third, the patient is asked about his daily work—the specific type of motion used, the estimated weight of the objects lifted, and the frequency with which such objects are lifted. Fourth, the general well-being of the patient is established, noting whether he has had an increase or decrease in weight, whether he is easily fatigued, or whether he has a general lassitude. Fifth, if the patient is a woman, it is well to note whether or not she has been pregnant; if so, whether the pregnancy was successfully or unsuccessfully completed or whether delivery was from below or by Cesarean section makes no difference as far as instability in the back is concerned.

After the general history has been taken, orthopedic examination of the back, following the procedures outlined under Examination of the Back (p. 238), is carried out. In general, examination of the back reveals rather nonspecific signs, and therefore exact diagnosis depends in large measure upon the history and the findings on the roentgenograms

Unstable Low Back

Unstable Low Back Due to Spondylolisthesis.—Spondylolisthesis is a mechanical defect of the low back and is located between L-5 and the sacrum or between L-4 and L-5. Fundamentally, an anterior shift of the entire vertebral column takes place at L-5 on the sacrum or at L-4 on L-5, as the case may be. Characteristically there is a defect in the bone formation in the posterior bony

patients in whom conservative therapy has failed to give relief, the practitioner should consult an orthopedist for futher study of the condition by myelography, with the consideration of operative treatment. Operative treatment may be one of several procedures: excision of the loosened and abnormal facet and the fibrocartilaginous mass which may be exerting pressure on the nerve root; removal of a protruding intervertebral disc; or either excision of the fibrocartilaginous mass or a ruptured intervertebral disc or a spinal fusion from vertebrae above the area of spondylolisthesis down onto the sacrum.

Unstable Low Back Due to Anomalous L-5.—Insofar as the vertebral bodies are concerned, the region of L-5 is a transition between the fused mass of the sacrum and the separate vertebral bodies of the lumbar spine. There-

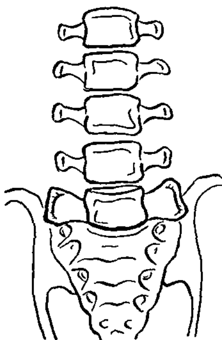


Fig 132 —Anomaly of L-5. Note that in this particular case there is sacralization on both sides of the vertebral body.

fore, it is no wonder that at times L-5 may be abnormally shaped, so that it has certain characteristics not only of the fused sacral mass, but also of a normal lumbar vertebra. One common abnormality is that the transverse process on one side is abnormally large and apparently reaches the wing of the ilium. (Fig. 132.)

In association with such a change the facets may be abnormally directed as well. As in the condition of an abnormally directed facet, the complaint is of spontaneous pain in the back, with or without sciatica. That is, the pain is usually dull, nagging, and annoying, but not disabling. Objective findings upon examination are conspicuously absent. With the patient erect, range of motion is normal, and the pain is most likely to occur during forward flexion or upon assuming erect posture after forward flexion. Palpation may reveal a vague and

sociated ruptured intervertebral disc. In patients in whom the pain is not particulary severe and whose work is not likely to aggravate the underlying condition, conservative therapy is indicated. The patient should sleep on a firm mattress with a board beneath it and wear a good support for the low back.

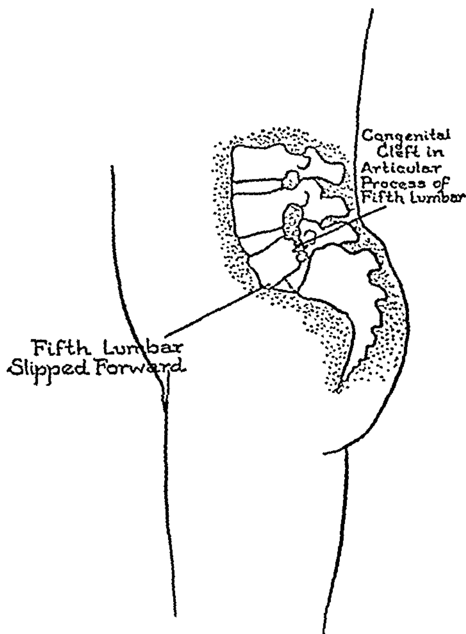


Fig. 131.—Spondylolisthesis (Type II) (From Larson, C B., and Gould, M · Calderwood's Orthopedic Nursing, 1957, The C V. Mosby Co)

Exercises designed to strengthen the low back should be followed as a routine. The patient should not be allowed to gain weight, simply because an increase in weight adds to the mechanical difficulties of the low back. In patients with markedly severe pain whose disability may prevent them from working and in

patients in whom conservative therapy has failed to give relief, the practitioner should consult an orthopedist for futher study of the condition by myelography, with the consideration of operative treatment. Operative treatment may be one of several procedures: excision of the loosened and abnormal facet and the fibrocartilaginous mass which may be exerting pressure on the nerve root; removal of a protruding intervertebral disc; or either excision of the fibrocartilaginous mass or a ruptured intervertebral disc or a spinal fusion from vertebrae above the area of spondylolisthesis down onto the sacrum.

Unstable Low Back Due to Anomalous L-5.—Insofar as the vertebral bodies are concerned, the region of L-5 is a transition between the fused mass of the sacrum and the separate vertebral bodies of the lumbar spine. Therefore, it is no wonder that at times L-5 may be abnormally shaped, so that it has certain characteristics not only of the fused sacral mass, but also of a normal lumbar vertebra. One *common abnormality is that the transverse process on one side is abnormally large and apparently reaches the wing of the ilium.* (Fig. 132.)

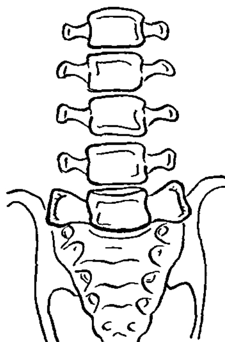


Fig. 132.—Anomaly of L-5. Note that in this particular case there is sacralization on both sides of the vertebral body.

In association with such a change the facets may be abnormally directed as well. As in the condition of an abnormally directed facet, the complaint is of spontaneous pain in the back, with or without sciatica. That is, the pain is usually dull, nagging, and annoying, but not disabling. Objective findings upon examination are conspicuously absent. With the patient erect, range of motion is normal, and the pain is most likely to occur during forward flexion or upon assuming erect posture after forward flexion. Palpation may reveal a vague and

poorly localized feeling of discomfort in the general area of the lumbosacral ligament. With the patient supine, straight leg raising is ordinarily normal, and the lumbosacral test is likely to cause a certain discomfort. The reflexes and sensation in the lower extremities and the power of the extensor hallucis longus are normal. The roentgenogram is the surest means of making a correct diagnosis.

Treatment of this condition is the same as the treatment for the patient with back pain due to an abnormally directed facet. In general, a firm mattress with a board beneath, the restriction of unusual activities, and the use of a low back support are recommended. It is also well to advise a group of postural exercises designed to strengthen the muscles in the area. For the rare patient who develops a rather marked disability, severe enough that his livelihood is threatened, consultation with an orthopedist should be held.

Unstable Low Back Due to Abnormally Directed Facets.—The zygapophyseal joints or facets, as they are also called, are the small joints above and below the posterior bony arch of each vertebra. They are ordinarily directed more or less in an anteroposterior plane, but with an oblique inclination to their surfaces so that they act as a stabilizing influence on the vertebral column. Occasionally, in the lumbosacral region, the facets on the right may be directed in a different plane from the ones on the left; that is, one facet may be directed almost horizontally, whereas the other may be directed almost anteroposteriorly. Under such a circumstance a certain instability of the lumbosacral area is possible, as are abnormal rotational stresses at this site. The patient may complain of a dull, nagging, annoying, low back pain which is spontaneous, is intermittent, and particularly likely to occur following an increase in physical activity, such as in bowling, basketball, or other sport.

Examination reveals findings similar to those in back pain due to obesity or to lax ligaments. That is, the range of motion, including forward flexion, extension, side-to-side bending, and rotation to the right and to the left, is normal in degree, and only some of the movements cause pain. The pain is not pressing nor acute but rather is vague, dull, and poorly localized. The patient may state that when he stands erect after being in a bent or crouched position for some time there is a "sore stiffness" in the low back. Palpation of the lumbosacral region may also yield no positive findings or at best only some vague discomfort generally located in the middle of the region, including the interspinous ligaments of L-5 to S-1 and the insertions of the erector spinae muscles overlying each side of the sacrum. With the patient supine, straight leg raising on both the right and the left is normal in degree and ordinarily does not cause much pain, although occasionally the patient may state that it is somewhat uncomfortable. The lumbosacral test is more likely to produce pain, and the reflexes and sensation in the lower extremities and the power of the extensor hallucis longus are normal. In other words, the back pain is not pressing in character. Clinical examination reveals very little of an objective nature. Pain is more likely to be produced by forward flexion of the back, by extension of the back from the flexed position, and by the lumbosacral test. The roentgenograms are the most helpful means in making a diagnosis. They reveal the abnormally directed zygapophyseal joints in the lumbosacral region.

Treatment of a patient with low back pain due to instability of abnormal facets varies somewhat, depending upon the severity of the pain. As has been noted, the pain ordinarily is not severe and the patient is not ordinarily badly disabled. Such patients are advised to sleep on a firm mattress with a board beneath it. It is also wise to limit the patient's participation in sports to some degree. If the pain is more acute, support for the low back is recommended—a surgical corset for women and a canvas support for men. If the patient is a man who works at heavy labor and of necessity must use the low back extensively, he should be taught various correct ways of lifting heavy objects. A low back support, flexible enough to allow freedom of movement, yet strong enough to provide adequate support, should be worn. He should be taught a series of graded exercises for specific muscles to increase the muscle power in the low back. This latter recommendation may seem anomalous when considering a man engaged in heavy labor, but nonetheless many men who are otherwise quite muscular do not have sufficient strength in the muscles used in special actions, and it is the muscles used in such movements which should be strengthened. If the patient is quite severely disabled by repeated episodes of low back pain and is having difficulty carrying out work, consultation with an orthopedist should be held.

Unstable Low Back Due to Lax Ligaments.—Instability in the low back can result not only from spondylolisthesis, anomalous L-5, and abnormally directed facets, but also from laxity in the supporting ligaments of the low back.

During pregnancy the ligaments of the low back (pelvis) normally become lax. After gestation is completed the ligaments may not return to their former tautness. Since the laxity is probably due to a hormonal disorder, as far as the instability in the back is concerned it makes no difference whether the pregnancy was successfully concluded, whether there was a vaginal delivery, or whether a Cesarean section was performed. A former pregnancy can result in an unstable low back, with chronic pain.

Although the nucleus pulposus is not a ligament, it makes a very important contribution to the support and stability of the vertebral column. Degeneration of the intervertebral disc allows undue mobility of the vertebrae, and the ligaments surrounding such vertebrae must of necessity be lax. Chronic low back pain results from the instability in association with the degeneration of the intervertebral disc. Degeneration of the intervertebral disc may be caused by normal wear and tear and by the normal aging process, but it can be caused by a single trauma of some magnitude or from repeated injuries to the back so minor that they pass unnoticed at the time. For these reasons we discuss the condition here rather than under Traumatic Injuries to the Back, although trauma can at times be the leading etiologic factor.

It should be understood that we do not refer to rupture or protrusion of the intervertebral disc. The disc may be torn within its body, with resultant hemorrhage and later degeneration. The ensuing abnormal mobility in the vertebral body may be so great that roentgenograms taken in special positions reveal what appears to be a slipping of one vertebra upon another. Some call this condition pseudospondylolisthesis. In essence, however, the difficulty is unstable low

back due to the laxity in one of the supportive elements of the vertebral column. (See also Chronic Strain of the Muscles, Ligaments, and Joints under Traumatic Injuries to the Back.)

The presenting complaint in unstable low back due to lax ligaments is usually a dull, nagging, annoying pain which can be so severe at times as to be disabling. Clinical examination yields only a few findings which are rather general There is usually tenderness over the interspinous ligaments of the low back. The range of forward flexion, extension, rotation, and side-to-side bending is ordinarily normal, and muscle spasm is not usually apparent. The patient complains of pain on forward flexion, however, and also complains of pain when the lumbosacral test is carried out. Neurologic signs in the lower extremity are, of course, negative. In degenerative intervertebral disc the ordinary roentgenograms usually show narrowing of the intervertebral space and may show hypertrophic, reactive changes in the adjacent surfaces of the affected interspace. In pseudospondylolisthesis special x-ray pictures taken with the patient in forward flexion and extension may reveal the abnormal mobility of the vertebrae.

In general treatment is conservative and consists of the application of support for the low back, modification of the patient's physical activities to conform to his altered capacity, and the use of a firm mattress on the bed (with a board beneath). At times spinal fusion can be considered if the disability is serious enough.

Strain Due to Obesity

The complaint of back pain without sciatic pain is common in people who are obese. The pain is dull and nagging, and ordinarily not a sharp, acute, disabling type. It is usually in the area of the lumbosacral joint. The patient ordinarily feels more pain on arising than during the rest of the day. The patient is ordinarily a woman who does not customarily wear a corset or any other support. Furthermore, the history will reveal that she sleeps on a soft mattress. Such a mattress sags during the night and has the same effect on the patient as if she stood in an abnormal position for seven or eight hours. The roentgenograms are of course negative. With the patient erect, the forward flexion is limited only by the obesity of the abdomen and not by muscle spasm. No acute pain is produced by any motion, whether extension, side-to-side bending, or rotation. With the patient supine, straight leg raising is consistent with forward flexion and is ordinarily again limited by abdominal obesity. The lumbosacral test may be mildly positive inasmuch as the obesity probably places an undue strain on the lumbosacral ligament over a long period of time. The reflexes and sensation in the lower extremities are normal, as is the power of the extensor hallucis longus. Back pain due to the strain of obesity is distinguished from other conditions by the fact that there are no particular findings upon examination other than the obesity and lordosis due to poor posture. Negative x-ray pictures distinguish this mechanical disturbance from other conditions, such as osteomyelitis, Pott's disease, rheumatoid arthritis, and tumor, as well as from other mechanical disturbances, such as spondylolisthesis and abnormal shape of the bones and joints of the low back.

Treatment consists of placing the patient on a strict weight-reducing regime and advising adequate support for the low back, such as a surgical corset with sufficient boning. The patient is also advised to sleep on a firm mattress with a bedboard underneath which extends the entire length and breadth of the mattress. A program of muscle building exercises should also be recommended.

Faulty Posture (Increased Lumbar Lordosis and Increased Dorsal Kyphosis)

Another of the mechanical disturbances which may produce low back pain is poor posture, manifesting itself in increased lumbar lordosis in association with a corresponding degree of dorsal kyphosis. There are two general situations in which posture is the basis of the complaint. The first occurs in childhood, and the complaint is usually made by the parent, who complains of the manner in which the child stands. In such a circumstance the child does not ordinarily complain of pain. The second occurs in adulthood, and the patient complains of pain but does not think of his poor posture. Persons with increased lumbar lordosis often are also obese, and therefore there are two reasons for the development of their complaint.

In examining a child whose parent complains of the posture of the child, the physician is likely to find nothing except the increase in lumbar lordosis and in dorsal kyphosis. That is to say, range of motion in all directions is normal, and there are no areas of tenderness. Straight leg raising and the lumbosacral test are also normal. The roentgenograms are negative or reveal the increase in lumbar curvature and in dorsal kyphosis, but no bony abnormality or disease process of the vertebral bodies is observed.

Treatment of a child with poor posture consists of exercises designed to flatten the lumbar curve and to achieve a better positioning of the shoulders, head, and neck. Such exercises must be persisted in over a long period of time, and improvement occurs only very gradually. Exercises are superior to a support in treating a child, since a support tends to weaken the musculature and adds to the tendency toward poor posture.

In an adult who complains of low back pain due to increased lumbar lordosis, examination reveals very little except the increased lumbar lordosis, which is apparent upon inspection. That is, clinical examination reveals a normal range of motion without pain or with very vague pain located rather diffusely in the low back. No areas of tenderness are found. Straight leg raising is normal. The lumbosacral test is usually negative, but upon occasion it may reveal some very mild pain, such as a vague discomfort. Reflexes and sensation in the lower extremities are normal. Roentgenograms are not revealing or at the most show an increased lumbar lordosis.

Treatment consists of a program of carefully followed and faithfully performed postural exercises which are designed to flatten the lumbar curve and to position the shoulders more normally. A simple way to accomplish this is to have the patient balance himself upon the heels. Unlike the treatment in childhood, it may be necessary, in addition, for the patient to wear a low back support in order to get sufficient relief from pain. A reducing diet should be advised if the practitioner believes that obesity is one of the contributing factors.

Hypertrophic Change With or Without Radiculitis

Hypertrophic change is another mechanical disturbance which very commonly causes back pain. The patient complains of a vague, dull, annoying, and rather diffuse pain not only in the lumbosacral region, but also in the entire lumbar spinal area. The pain not only involves the low back and lumbar spine area, but also is likely to be associated with radicular pain. That is, the patient may complain of a radiation of the pain around the flank and into the lower abdomen, the buttocks, or the sciatic nerve distribution. The patient is usually in an older age group and may show stigmas of hypertrophic change elsewhere, such as in the distal interphalangeal joints of the fingers. Examination will frequently reveal that the degree of limitation of motion (the amount of stiffness in the low

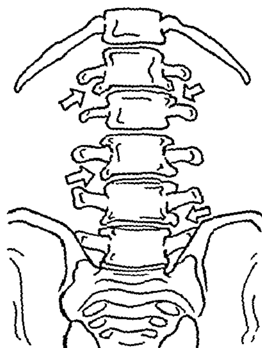


Fig 133 —Hypertrophic changes in the lumbar spine

back) seems out of proportion to the severity of the complaint. That is, the stiffness in the low back seems more marked than the patient's complaint indicates. While this is true, it is also true that during exacerbations a patient with hypertrophic arthritis of the lumbar spine may suffer pain quite as severe as that in a more acute disturbance, particularly if there is a radicular component. Usually, forward flexion is moderately limited and segmentation of movement in the lumbar spine is not so good as normal, although muscle spasm may not be particularly apparent. There are spotty areas of tenderness to palpation in the low back over the interspinous ligaments and the erector spinae muscle masses, although the tenderness is not so acute as that due to injury and is more widely distributed. Extension of the spine is limited, again by a loss of motion seemingly within the vertebral column and the associated zygapophyseal joints rather than

by muscle spasm or pain. The same is true of side-to-side bending. Rotation to the right and to the left is limited, perhaps asymmetrically, but not particularly because of spasm. With the patient supine, straight leg raising may be limited on both sides, more particularly on the side on which the radicular pain, such as sciatica, occurs. The lumbosacral test is likely to cause pain. Reflexes and sensation are usually normal, even in spite of the fact that the patient may be complaining rather bitterly of sciatic pain. The x-ray pictures (Fig. 133) reveal the irregularity of the vertebral centra, spur formations along the margins of the vertebral bodies, and particularly encroachment of the bony spurs upon the neural foramina.

Treatment, in general, is conservative and is dependent somewhat upon whether or not radiculitis occurs in association with the low back pain. In general, a firm mattress and a bedboard are used. A support for the back is helpful at times. The patient may get symptomatic relief from diathermy, infrared treatments, or from hot baths. If the process is sufficiently severe, a short period of bed rest may be advantageous. At times, the use of a low back plaster cast for a short period may prove more efficient than the conventional back support. If the patient is obese, which is quite likely in this circumstance, a reducing diet is recommended. If the radiculitis appears quite severe, bed rest, with traction on the affected extremity, usually brings the process under control. In the management of hypertrophic arthritis of the low back or hypertrophic arthritis associated with radiculitis, it should be realized that even though symptomatic relief is obtained, the irregularity of the vertebral bodies and the neural foramina has not been corrected, and therefore the pain and disability are likely to recur in the future. Furthermore, the benefits to be derived from a more or less steady and extensive administration of salicylates should not be overlooked.

Osteomyelitis

Upon occasion a patient complains of back pain, usually without sciatic pain and has a history of a progressive increase in pain apparently unrelated to activity, although at times increased activity may make the condition somewhat worse. He frequently does not appear to be particularly ill but may complain that he has experienced episodes of fever. When examined, he may have a slight or moderate elevation in temperature. Tenderness directly over the involved vertebra is present. Motion is limited by muscle spasm, accompanied by pain, and includes flexion, extension, side-to-side bending, and rotation. With the patient supine, straight leg raising is likely to be limited. The lumbosacral test is not particularly likely to cause pain unless L-5 is the involved vertebra. The roentgenograms may show destruction of a considerable portion of a vertebral body, with either a symmetrical or a wedge-shaped collapse. It should be apparent that osteomyelitis in the adult is quite different from that in the child, in that it is far more insidious in its onset, is far less acute, and ordinarily does not produce as severe a systemic reaction as does osteomyelitis in the child. Furthermore, in the adult osteomyelitis is likely to occur in the flat bones, such as the vertebrae, pelvis, and skull, while the disease in the child occurs in the metaphysis of the long bones, particularly the distal and proximal tibia, the distal femur, and

the proximal humerus. In diagnosing osteomyelitis involving a vertebral body, the practitioner should pay particular note to the fact that the process is spontaneous and not associated with trauma and that it becomes progressively more severe in its general over-all course, in spite of the fact that activity may from time to time cause some minor exacerbations. The history differs from that obtained in disorders due to mechanical disturbances, such as those due to obesity, or unstable back (as a result of lax ligaments, abnormal facets, anomalous L-5, or spondylolisthesis), hypertrophic arthritis, and faulty posture, in the history of a gradual, progressive increase in pain. However, as far as the history is concerned, almost identical histories are given by patients with back pain due to tuberculosis and primary or metastatic tumor—a gradual and progressive increase in pain, regardless of activity, although aggravated somewhat from time to time by particular activities. The differentiation between osteomyelitis, tuberculosis, and primary or metastatic tumor is based, among other things, on the roentgenographic findings. Tuberculosis, for example, is usually accompanied by positive skin tests for tuberculosis and the discovery of the primary lesion in the lung or gastrointestinal tract. Osteomyelitis is distinguished from primary or metastatic tumor of the vertebrae by elevated temperature (although some patients with tumors have an elevation in temperature also), by multiple neoplastic foci in other vertebrae (if such can be found), by foci of destruction by the tumor in other parts of the body, such as the skull or long bones, and by the discovery of a primary tumor in some other organ, such as the breast, lung, or kidney.

In the treatment of osteomyelitis of a vertebral body, massive doses of antibiotics are administered over a prolonged period of time. The patient is put at bed rest and placed in a bony cast; later, when he becomes ambulatory, he wears a brace. If the process seems to be progressive in spite of such treatment, spinal fusion may be indicated.

Tuberculosis

At times, a patient presents with a complaint of back pain which has the same type of history as osteomyelitis and primary or metastatic tumor. He complains of a progressive, continuous increase in back pain which is perhaps at times aggravated and increased by a special activity. He may or may not appear to be chronically ill Examination reveals general findings quite the same as in osteomyelitis—a diffuse and rather poorly localized vague pain around the area of the involved vertebra. The spinous process of the involved vertebra is tender to palpation, and, if the disease process is sufficiently advanced, gibbus formation may be present. The range of motion is likely to be painful regardless of the motion performed. Straight leg raising is likely to result in muscle spasm and to be limited The lumbosacral test is likely to be negative, unless L-5 is involved. Ordinarily, there are no sensory or reflex changes in the lower extremities. The roentgenograms reveal narrowing of the intervertebral space between the involved vertebra and the adjacent vertebra. The roentgenograms also reveal areas of destruction and, ordinarily, a wedged-shaped collapse of the vertebral body. Paravertebral shadows are likely to be present. Pulmonary or gastrointestinal tuberculosis is also likely to be found, since tuberculosis of the bone must, by its nature,

be secondary to a focus elsewhere in the body. The patient ordinarily has a low-grade fever. Tuberculosis is distinguished from osteomyelitis by a positive skin test, by finding tuberculous lesions in the lungs, or by a history of the ingestion of unpasteurized milk. Differentiation at times may be very difficult. Tuberculosis is distinguished from primary or metastatic tumor by the presence of destructive lesions due to tumor elsewhere in the skeleton, particularly in the skull or the long bones, and by the presence of a possible primary tumor, particularly in the lungs, breast, kidney, or prostate.

Treatment of tuberculosis is divided into general systemic treatment and specific treatment of the local lesion. The patient is placed at bed rest, a high caloric, high vitamin diet is prescribed, and streptomycin and para-aminosalicylic acid (PAS) are administered. A plaster body cast is applied to immobilize the affected site. If, in spite of these measures, progression of the lesion continues, spinal fusion is considered. Some now believe that cold abscesses, if they appear, should be incised, drained, and curetted of necrotic debris in much the same manner as is a suppurative abscess.

Rheumatoid Arthritis

Patients suffering from rheumàtoid arthritis of the back frequently are classified as having Marie-Strümpell arthritis which, characteristically, occurs in young male adults, especially if there has been an antecedent prostatitis. The usual complaint is of a steady, continuous back pain, with little or no relief. There may be some exacerbations and remissions, but, in general, the pain is steady and progressive, accompanied by a gradual stiffening and disability of the back. In general, the process begins in the low back in the area of the sacro-iliac joints and the zygapophyseal joints of the low lumbar spine. This is the region about which the patient ordinarily complains initially. Although at first it may appear that rheumatoid arthritis in the low back has the same characteristics as osteomyelitis, tuberculosis, and primary or metastatic tumor, it will be found that the pain in rheumatoid arthritis does not become progressively worse in *severity*, as it does in the other conditions. Rheumatoid arthritis is likely to smolder along upon a given plateau or level of discomfort or pain which is not ordinarily as great as that in osteomyelitis, tuberculosis, and tumor. The outstanding characteristic is the complete loss of motion in the involved area of the back. The size of the involved area of course depends upon length of duration of the arthritic process Generally, by the time the patient seeks medical aid, little, if any, real motion remains in the lumbar spine. When the patient is requested to do forward flexion from an erect position, he may be able to do so quite well from the standpoint that the finger tips may reach almost to floor level. It will be noted, however, that there is no segmentation of movement in the lumbar spine; that is, the spine moves en bloc. In medical jargon this is called "poker spine." Lateral bending within the lumbar spine is impossible if the process is sufficiently long standing. The same applies to rotation and extension. With the patient supine, straight leg raising is normal if, during forward flexion in an erect position, the patient has been able to reach almost floor level

with the finger tips. The lumbosacral test may be normal. The reflexes and sensation in the lower extremities are normal. Decrease in chest expansion is one of the earliest signs of Marie-Strümpell arthritis. Therefore, the chest should be measured. It is well to remember that rheumatoid arthritis is a process first of synovial inflammation and then gradual joint destruction, with eventual fibrous and bony ankylosis of the involved joint. Therefore, it is common for the pain to subside and disappear as the back grows progressively stiffer and more ankylosed. Either partial or complete destruction of particular joints is noted on the roentgenograms. This partial destruction of a joint appears on the film as a cloudiness or as an indistinct area. The ankylosis is manifest by a complete



Fig 134 — Marie-Strumpell arthritis Both hip joints, both sacroiliac joints, and the zygapophyseal joints have been destroyed and have undergone bony ankylosis Note the calcification of the vertebral ligaments. No motion in this portion of the back and in the hips is possible.

absence of the joint space. The changes are most marked in the sacroiliac joints and the zygapophyseal joints Furthermore, calcification of the anterior longitudinal ligament and the ligaments binding the lumbar vertebrae together may be so extensive as to give the appearance of a single block of bone over a considerable number of vertebral bodies (Fig 134.)

In the treatment of Marie-Strumpell arthritis several factors must be taken into consideration. If the process is of recent origin, the practitioner should keep in mind that there is a tendency for flexion of the spine to occur and to persist as an ankylosed deformity. Therefore, a firm mattress, with a board beneath it, and postural exercises to achieve and maintain good strength in extension of the spine are advised; in addition, a brace to control progressive flexion, particularly in

the dorsal spine, is prescribed. If the process seems to be rather malignant, sometimes, the patient is hospitalized and placed in a position of hyperextension of the spine, using a Bradford frame. Further treatment consists of the administration of ACTH or cortisone. If the arthritic process has already resulted in a bad flexion deformity of the spine, which is fixed by ankylosis, it is possible to correct the deformity by performing an osteotomy at the lamina and facets. This operative procedure should be performed only by one of the very few specialists who are particularly trained in this field.

Primary or Metastatic Tumor

The practitioner should be on his guard at all times against a type of history of progressively increasing pain in the back, with or without radicular components. One of the medical characteristics of primary or metastatic tumor is that the back pain grows continuously worse, more pressing, more severe, and more disabling. Another characteristic is that the severity of the pain gradually increases, regardless of activity. That is, while an increase in activity may magnify the pain somewhat, nevertheless it progresses in spite of the fact that activity is restricted. When a patient with this type of history is encountered, the practitioner should consider osteomyelitis, tuberculosis, or, more especially, primary or metastatic tumor as likely diagnoses. The pain in rheumatoid arthritis, although long standing, is not likely to be so acute, so progressive, or so insistent as the pain in a primary or metastatic tumor. The pain in osteomyelitis and Pott's disease is usually accompanied by an elevation in temperature. As a rule the temperature is normal in patients with a primary or metastatic tumor of the vertebrae. The pain in a primary or metastatic tumor is more severe than that in a mechanical disturbance of the back and is progressively severe during a given period of time, whereas in a mechanical disturbance, even though the pain may be long lasting, with some exacerbation, it does not become progressively worse Pain in a primary or metastatic tumor is not likely to be sudden in onset. In the beginning, x-ray pictures of the area of complaint are likely to be normal and reveal no destruction. They may be negative for as long as three to four months after the onset of symptoms and should be repeated often. Therefore, repeated clinical examination and careful follow-up of the patient are sometimes necessary if a primary or metastatic tumor is suspected. It is well to keep in mind that the pain may be as far as three segments away from the site of the destruction. Therefore, x-ray pictures of a sufficiently large area should be obtained. In examination of the patient with a primary or metastatic tumor, one of the striking features is that the objective signs and the severity of the pain both seem out of proportion to the findings on the x-ray pictures. That is, the patient may cry out as if in severe pain during a straight leg raising test, and there may be muscle spasm which, in the presence of a negative x-ray picture, sensitivity may lead the examiner to believe that the patient is exaggerating. A rather large area is likely to be tender to palpation. Range of motion, with the patient erect, is likely to be severely limited. Muscle spasm is obvious, and in the early stages reflexes in the knee and ankle may be normal, as also may be the sensitivity to pinprick in either lower extremity. In order to arrive at a diagnosis of

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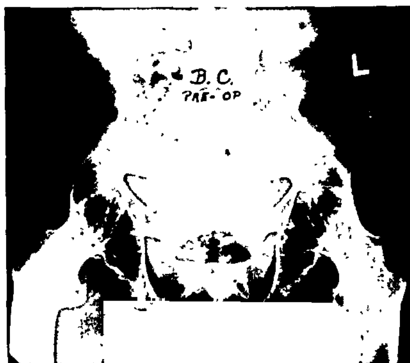


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ability. However, such seems to be the case. Since the doctor commonly will be confronted with patients who exaggerate a real disability and those who malinger, he must be somewhat versed on procedure under the circumstances. In this discussion we propose to present the practitioner with sufficient information so that he can distinguish a patient who exaggerates or malingers from one who has a genuine complaint. We advise a practitioner who suspects that he may have a malingerer to refer the patient to a specialist. It is not particularly well known that the specialist usually does not have difficulty in determining the truth, even when the condition involves an injury or disorder of the back.

There are four ways in which the practitioner can distinguish the genuine patient from the malingerer: (1) the attitude of the patient, (2) the type of history, (3) the presence of objective findings on examination, and (4) the pattern of the physical findings upon examination.

First, let us consider the attitude of the patient. The genuine patient with a real disability is characterized by a pleasant, courteous attitude. On the other hand, the malingerer is usually ill at ease, nervous, and quarrelsome and frequently bursts out in the midst of the history with angry remarks to the effect that his own doctor has all the information and that there is no point in repeating the history. Furthermore, by his choice of words while giving the history, he frequently attempts to impress the doctor with the magnitude of the disaster. It is also characteristic that he denies the examiner the right to review previous roentgenograms of the very area about which he complains so bitterly, frequently stating that his lawyer is the only one who can grant permission for a review of previous films. The genuine patient does not hesitate to allow anyone to see previous roentgenograms or to answer questions concerning the history and is not overwhelmed by the magnitude of his physical damage.

The second way to distinguish the genuine patient from the malingerer is by the type of history related. A genuine patient gives a history which in general is rather brief and, in essence, a description of a particular traumatic occurrence which resulted in a particular disability. From past experience with his own patients the examiner believes this history to be true because he knows that a given traumatic occurrence results in one of several well-known injuries. On the other hand the malingerer will frequently give a long and involved history in which he definitely blames and is antagonistic toward the persons alleged to be responsible for his injury and disability. It should immediately be apparent, however, that the traumatic experience described by the malingerer has resulted in a group of complaints which the examiner, from past experience, knows cannot be real. Sometimes it is difficult to imagine how a given traumatic situation could possibly be responsible for the purported injury.

The third way to distinguish between the genuine patient and the malingerer is by a consideration of the objective findings elicited on physical examination. An objective finding is one which the examiner knows the patient cannot possibly produce at will—a finding that the examiner can see or feel himself. For example, an x-ray picture which reveals a compression fracture of a vertebral body leaves no doubt that there is a reasonable basis for pain. (However, exaggeration of pain is quite possible even in the presence of such an objective finding.) The

primary or metastatic tumor, it may be necessary to perform a spinal tap to observe the dynamics of the spinal fluid, and to obtain a protein determination on the fluid. In the later stages, the x-ray pictures may reveal destruction of the vertebral bodies, in either single or multiple vertebral centra, and a symmetrical collapse of one or more vertebral bodies due to the extensive destruction of the bone. In addition, they may also reveal a pathologic fracture with a typical wedge-shaped vertebra, the collapse having occurred at the anterosuperior plate of the vertebral body.

In a fairly advanced condition, there may be weakness in various muscle groups in either one or both lower extremities, and certain reflex as well as sensory changes may be apparent. In a still more advanced condition, a frank paraplegia may appear, together with loss of control of both the urinary bladder and the bowel. The metastatic tumor which produces lytic lesions is often likely to be primary in the lung, the breast, or the thyroid gland. Metastatic lesions due to carcinoma of the prostate are likely to be osteoblastic.

A search to determine the primary site of the tumor should be made and includes examination of the breast, x-ray pictures of the chest, retrograde pyelograms, and, in the male, rectal examination as well for carcinoma of the prostate. Multiple myeloma is one of the common primary tumors of the bone which is likely to give a clinical picture of a progressive increase in pain eventually ending in radicular pain and perhaps paraplegia. The diagnosis of multiple myeloma is made by taking x-ray pictures of other bones, particularly in the skull, to discover lytic lesions. The diagnosis may be aided by performing a sternal biopsy and finding a reversal of the albumin-globulin ratio and by carrying out repeated tests for Bence Jones proteinuria. At least seven tests should be made. It is of note that only about 50 per cent of the patients with multiple myeloma reveal positive Bence Jones proteinuria. An intraspinal primary tumor may give rise to the same clinical picture, although there is no sign of bone disturbance since such a tumor is primarily one of the nerves, spinal cord, or spinal cord covering.

Treatment of a primary or metastatic tumor of the vertebral column or spinal cord is in general highly specialized. If paralysis impends, a decompression laminectomy may spare motor function and control of the bowel and the urinary bladder long enough for x-ray therapy to be instituted and in that way be of benefit. If there is a collapse of a vertebral body, x-ray therapy is given, and the back is protected by the application of a plaster cast or a brace. Other treatment depends upon the particular tumor and circumstance.

MALINGERING AND EXAGGERATION IN BACK PAIN

An insurance company may request the practitioner to examine a patient who claims that he has sustained a back injury. No doctor enjoys the prospect of appearing foolish for having believed a patient's story concerning a physical disability, only to discover incontrovertible evidence to the contrary. For some unknown reason the back is the commonly chosen area for which fraudulent disability claims are made. Equally difficult to understand is why the back is the commonly chosen area for exaggeration of an admittedly real organic dis-

We advise the practitioner to use the four various means just discussed in forming a preliminary opinion as to whether a patient is genuine or whether he is exaggerating or malingering. If exaggeration or malingering is suspected, the practitioner is well advised to refer the patient to an orthopedist. To summarize, a genuine patient is characterized by a pleasant, cooperative attitude, a history of a traumatic injury which results in a disability that is compatible with the physician's past experience with other patients, objective evidences of injury, and an asymmetrical pattern of physical findings. A probable malingerer is ill at ease and is characterized by a noisy, surly, quarrelsome attitude, a history of a traumatic injury incompatible with the severity of the alleged disability, lack of objective findings of an organic disturbance, and a symmetrical pattern in the limitation of motion and diminution of sensitivity to pinprick. Sometimes a patient does not malinger but simply exaggerates a real, although relatively insignificant, physical disability. Under this circumstance exaggeration may be the only feature which is apparent to the doctor, and injustice is done to the patient simply because of his own exaggeration.

absence of a reflex is also an objective finding. The examiner usually finds some objective evidence in the examination of the genuine patient, while he finds none in the malingerer.

The fourth way to distinguish the genuine patient from the malingerer is by the pattern of the physical findings, which include both objective and subjective responses. In the genuine patient there is usually one or possibly two areas of tenderness to pressure. Furthermore, the area of tenderness and pain is relatively limited and small. In the malingerer all sorts of structures and areas are tender to touch, and this is true no matter how gentle the touch. The area claimed to be tender by the malingerer is ordinarily much larger than that in the genuine patient. In the genuine patient there is a certain asymmetry in the findings (forward flexion and right lateral bending may be painful, but left lateral bending and rotation are not painful), while in the malingerer, there is a certain symmetry of pattern (all motions of the back are painful, not only forward flexion and extension, but also right and left lateral bending and rotation to the right and the left). Furthermore, the genuine patient does not make a loud complaint when asked to perform a painful movement or when an area of tenderness is touched. The malingerer, however, emits great cries of pain upon performing any motion requested by the examiner and in general is far more noisy than a genuine patient with a far greater disability. Therefore, although pain upon motion cannot be said to represent an objective finding, nonetheless, an asymmetrical pattern of findings suggests a genuine patient, and a symmetrical pattern suggests a malingerer. During examination for subjective findings, restrictions in motion in both the genuine patient and the malingerer are compared. The restrictions in a genuine patient are reasonable, as the physcian knows from past experience, and they tend to be asymmetrical; that is, forward flexion to about 30 or 40 degrees or more is possible, right lateral bending but not left lateral bending may be limited, or right lateral bending and left lateral bending may differ. In the malingerer the range of motion is symmetrically limited and limited to a degree of absurdity. For example, the malingerer may bend forward only 10 or 15 degrees, thinking that the doctor will be impressed by such an extensive limitation. The doctor of course knows that any such limitation postulates a process of ankylosis which extends from C-1 down the entire vertebral column and involves both hips as well. The doctor knows that if the limitation the patient exhibits were genuine, he could not possibly sit in a chair. This ridiculously severe limitation in motion is also symmetrical; that is, side-to-side bending to the right and left is limited to 5 or 10 degrees. Another significant physical finding, even though it is subjective, is the patient's response to pinprick. If diminution in sensitivity to pinprick does exist, it will be in well-recognized areas which are supplied by branches of nerves known to exist, such as numbness over the dorsolateral aspect of the foot. The malingerer claims diminution in sensitivity to pinprick over the entire circumference of an extremity, from the toes to the groin. The examiner knows that numbness in the anterior aspect of the thigh, high toward the groin, must come from nerve roots well above the area claimed to be injured. At times, the malingerer will state that as much as one half of the entire body, including the face, forehead, and scalp, are insensitive to pinprick

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Chapter Seven

*Disturbances of the Neck in the Adult**

It is fundamental for the doctor to realize that disturbances of the neck may produce pain not only in the neck, but also in various distributions in the upper extremity. As a matter of fact, the more severe pain may be in the upper extremity, and only by questioning the patient will the physician become aware that the neck is involved.

Disturbances of the neck are divided into two main groups, traumatic injuries and nontraumatic disorders. Conditions which are likely to produce pain not only in the neck, but also in the upper extremity are discussed.

Patients who sustain an injury to the neck may complain of neck pain alone or of neck and arm pain. That is, the pain is radicular, involving the upper arm, forearm, and hand. Furthermore, if there has been no injury, the pain may be in the neck alone or in both the neck and arm. Therefore, as a convenience, we have somewhat arbitrarily divided the discussion of neck pain and neck and arm pain into the following groups: (1) neck pain following injury but without arm pain, (2) neck and arm pain following injury, (3) spontaneous nontraumatic neck and arm pain, and (4) spontaneous neck pain without arm pain.

TRAUMATIC INJURIES TO THE NECK

Complaint		Likely Diagnoses	Page
Neck pain without arm pain following injury	(1)	Fractures or dislocations of cervical spine	281
	(2)	Rotary subluxation of cervical spine	284
	(3)	Ligamentous and/or muscle strain of neck	284
Neck and arm pain following injury	(1)	Ruptured intervertebral disc	285
	(2)	Ligamentous and/or muscle strain with traumatic radiculitis	285
	(3)	Hypertrophic arthritis with traumatic radiculitis	286

*See Chapter 1, Diseases or Affections of Childhood, (page 99), for a discussion of other conditions of the neck.

Fractures or Dislocations of the Cervical Spine

It is common today that in an automobile accident a patient sustains a whiplash injury to the neck. The head is thrown forward and then snapped backward due to the excessive mobility of the cervical spine as compared to the thoracic or lumbar spine. Because of this mobility, the cervical spine is particularly prone to dislocation when a person suffers a whiplash injury to the neck. However, compression fractures such as occur in the lumbar or dorsal spine are also possible, as are combinations of dislocations and fractures. The spinal cord is in serious danger of being injured if a fracture or fracture-dislocation exists. Therefore, since dislocation in the cervical spine is far more common than in the lumbar spine, a higher incidence of paralysis or paresis occurs in association with a fracture or dislocation of the cervical spine than in compression fractures of the lumbar spine.

The patient who sustains a whiplash injury to the cervical spine ordinarily complains of pain in the neck but not much of radicular pain. Occasionally a patient states that he felt a momentary, sharp, shooting pain which involved both upper and both lower extremities at the time of injury to the neck. This probably represents momentary impingement upon the spinal cord itself. It should be emphasized that if a patient seen at the scene of an accident complains of neck pain, it is very possible that he has sustained a fracture or dislocation of the cervical spine, with its attendant high risk of paraplegia or quadriplegia. Every effort should be made to maintain the patient's head and neck absolutely motionless during transportation and until x-ray pictures of the cervical spine have been obtained. If the x-ray pictures show that the injury is a compression fracture without an associated dislocation, treatment consists of traction in moderate extension for a period of time, and then application of a plaster cast, with incorporation of the head, neck, and thorax. The traction can be by either the head-halter method or the Crutchfield tongs method. If the x-ray pictures reveal a dislocation or a fracture-dislocation (Fig. 135), manipulative or open reduction can be attempted. Probably the safer method is the insertion of Crutchfield tongs (Figs. 136 and 137) and the application of head traction for a considerable period until reduction and healing are apparent. A plaster cast should be applied following the traction. Needless to say, in either a fracture or a fracture-dislocation of the cervical spine, repeated follow-up examinations should be made to detect any evidence of muscle weakness or change in the reflexes in both the lower and upper extremities. Patients with a fracture or fracture-dislocation associated with paralysis or paresis should be managed in cooperation with a neurosurgeon. Either Crutchfield tongs traction alone can be applied, or Crutchfield tongs traction in association with an immediate decompression laminectomy and/or open reduction of the dislocation can be performed. It seems that the prognosis is so grave in patients with a fracture or fracture-dislocation with paralysis that Crutchfield tongs and immediate decompression laminectomy perhaps offer as good a chance of recovery as a delayed decompression laminectomy. The nursing care of patients with paralysis is, of course, of special importance and will not be discussed here.

Chapter Seven

*Disturbances of the Neck in the Adult**

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TRAUMATIC INJURIES TO THE NECK

Complaint	Likely Diagnoses	Page
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	(2) *Rotary subluxation of cervical spine*	284
	(3) Ligamentous and/or muscle strain of neck	284
Neck and arm pain following injury	(1) Ruptured intervertebral disc	285
	(2) Ligamentous and/or muscle strain with traumatic radiculitis	285
	(3) Hypertrophic arthritis with traumatic radiculitis	286

*See Chapter 1, Diseases or Affections of Childhood, (page 99), for a discussion of other conditions of the neck.

In treatment of a fracture or dislocation of the cervical spine, particularly if the normal position has not been achieved and if the patient has escaped neurologic damage, spinal fusion is often carried out after the initial phases of treatment are completed in order to stabilize the mechanical disorder and to prevent further collapse of a compressed vertebra or further shifting of a partially dislocated vertebra, with its attendant danger of future cord pressure.

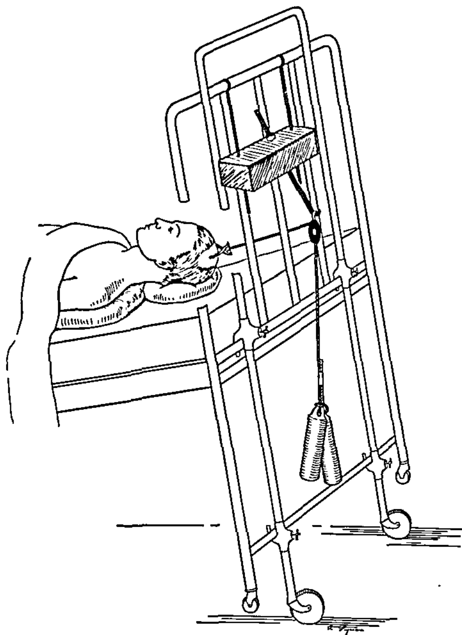


Fig 137 —Head traction by tongs. (From Larson, C. B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C V. Mosby Co)

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for four to six months and partially disabled for an additional six months. Under "Anticipated Loss" he may note that total disability is frequent.



Fig. 135 —Dislocation of the cervical spine.

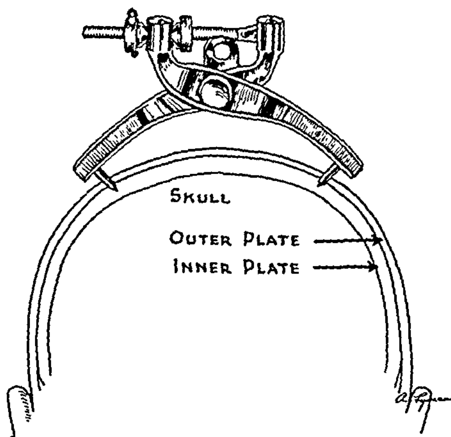


Fig. 136 —Crutchfield tongs (From Larson, C B , and Gould, M . Calderwood's Orthopedic Nursing, 1957, The C V Mosby Co.)

cast is one of the most effective means of reducing the pain and achieving complete recovery in the shortest period of time. Unfortunately, patients frequently object to this type of treatment, and the course of the process is greatly prolonged. Other methods of treatment include diathermy and support for the neck, either a cervical brace or a Thomas collar.

Ruptured Intervertebral Disc

If a patient has sustained an injury to the neck and complains not only of neck pain, but also of arm pain, the likely diagnoses include a ruptured cervical disc, ligamentous and/or muscle strain of the neck associated with traumatic radiculitis in the brachial plexus (stretch injury to the roots of the brachial plexus), and hypertrophic arthritis of the cervical spine with associated traumatic radiculitis in the brachial plexus. In a ruptured intervertebral disc, as in ligamentous and muscle strain with radiculitis, the x-ray pictures are negative or at most reveal a loss of normal cervical lordosis. These negative x-ray findings distinguish the conditions from hypertrophic arthritis with an associated traumatic radiculitis.

Clinical examination of a patient with a ruptured intervertebral disc reveals that forward flexion is limited by muscle spasm and pain. Inclination of the head toward the side with the arm pain is likely to increase the pain and produce an exacerbation of the arm pain, whereas lateral inclination away from the side with the arm pain is not likely to cause any pain. Examination of the upper extremity may reveal changes in the triceps, biceps, or periosteoradial reflexes and a sensory diminution along a definite nerve root pattern, such as the ulnar, median, or radial nerves. The diagnosis of a ruptured intervertebral cervical disc is confirmed by myelography. Myelography of the cervical spine is more difficult than that of the lumbar region and should not be undertaken unless it is essential to assure adequate treatment or unless surgical intervention is anticipated. A ruptured intervertebral disc is distinguished clinically from simple ligamentous and/or muscle strain with traumatic radiculitis by the fact that the pain in the upper extremity is not so diffuse and by the presence of more clear-cut neurologic findings, such as reflex changes and a sensory diminution over a specific nerve root distribution.

Treatment is conservative at first and consists of head-halter traction, with the patient in bed, for several weeks, followed by the application of a cervical brace which is worn for several months thereafter. If conservative therapy fails, myelography and operative intervention can be considered and should be undertaken if there is a *progression* of neurologic signs, a weakness of motor power in the upper extremity, or an *increase* in motor weakness involving the upper extremity.

Ligamentous and/or Muscle Strain With Traumatic Radiculitis

A patient who injures the neck sometimes complains not only of neck pain, but also of a diffuse pain in the entire upper extremity. The roentgenograms are negative or reveal only a loss of the normal cervical lordosis. Local findings

Rotary Subluxation of the Cervical Spine

Rotary subluxation of the cervical spine is particularly common in children but also occurs in adults. In a child the disturbance is likely to have a characteristic history. While running, the child turns his head suddenly to look at an object (perhaps over his shoulder), hears a "click," then discovers that he is no longer able to move the neck through the normal range of motion, and complains of pain in the neck. In an adult the history may be that the patient falls asleep in an awkward position in a chair and upon awaking complains of pain and stiffness in the neck. Rotation to one side is limited, whereas rotation to the other side is not. Clinical examination reveals that the patient appears to have a "stiff neck;" that is, one side of the neck is tender but the other is not. The patient may appear to have a slight or, sometimes, marked inclination of the head toward the affected side. Rotary motion is difficult toward the affected side and may not be possible at all from the midline toward the side with the pain, whereas rotary motion away from the side with the pain is normal or almost so. Lateral inclination of the neck may be normal on one side and markedly limited on the other. Flexion may be somewhat limited, but not so limited as either rotation or lateral inclination. X-ray pictures of the cervical spine may be entirely normal, although sometimes a partial subluxation can be demonstrated. The probable mechanical disorder in rotary subluxation of the cervical spine is actually a partial dislocation at the zygapophyseal joints; that is, one facet has ridden up somewhat on its opposing facet and is caught in this abnormal position.

Traction by means of a head halter for a period of two to four days ordinarily gives marked relief from pain and improvement in the range of motion. When range of motion appears almost normal and is accompanied by very little pain, the patient is taken out of traction and the affected part is protected by either a cervical brace or a plaster cast for an additional three to four weeks.

Ligamentous and/or Muscle Strain of the Neck

A patient who has been subjected to a whiplash type of injury to the cervical spine (see page 281) may complain of pain in the neck following the injury, and yet the roentgenograms may be negative. Examination reveals tenderness directly in the midline in the interspinous ligaments between one or more of the spinous processes of the cervical vertebrae. C-6 to C-7 is the usual location of a sharply localized area of tenderness Forward flexion is ordinarily limited and accompanied by muscle spasm and pain, which the patient states is of a "pulling" variety, and is likely to be bilateral in distribution. Often, there is evidence of some muscle strain as well, and there may be a point of tenderness within the muscles lateral to the midline. Ordinarily, rotation to the right and to the left may be somewhat uncomfortable, but not acutely painful, and may not be accompanied by spasm and may not be limited This is true unless a large area of muscle is strained on one side of the neck Under such circumstances, motions which stretch the strained muscles are painful and limited.

Treatment should be vigorous and adequate. Usually ligamentous or muscle strain of the cervical spine is difficult to treat. Immobilization by a plaster

on the neck and administer large doses of vitamin B_{12}. If the patient objects to both these procedures, perhaps he will accept head-halter traction set up at home which can be applied during the evening and all night.

NONTRAUMATIC DISORDERS OF THE NECK

Complaint	Likely Diagnoses	Page
Neck and arm pain	(1) Cervical rib and scalenus anticus syndrome	287
	(2) Hypertrophic arthritis with radiculitis	288
Neck pain without arm pain	(1) Stiff neck	291
Neck pain and intermittent pain and twisting of head, no arm pain	(1) Spasmodic torticollis	291

Cervical Rib and Scalenus Anticus Syndrome

At times a patient may complain of pain in the neck associated with rather sharp attacks of radicular pain in the upper extremity, usually along one special nerve distribution, such as the ulnar or median nerve. The attacks of both



Fig. 138.—Cervical rib.

neck pain and arm pain are characteristically intermittent. The etiologic factor may be either a cervical rib which catches the roots of the brachial plexus and the arterial supply to the arm or a compression of the brachial plexus and artery against the first rib in the interval between the rib and the scalenus anticus muscle. X-ray pictures of the cervical spine reveal the presence of a cervical rib (Fig. 138) but of course are negative in the case of a scalenus anticus syndrome. Positioning of the head away from the affected side and exerting pressure downward on the affected shoulder aggravates the radicular pain and

in the neck indicate ligamentous and/or muscle strain. There are areas of tenderness situated directly in the interspinous ligaments, particularly at C-6 to C-7. There may be some areas of tenderness on either side in the muscle masses. Motion which puts a stress on the muscles or ligaments causes pain and is likely to be associated with spasm, while motion which relaxes the muscles or ligaments is not likely to be painful. In addition, the patient complains of discomfort in the upper extremity, and yet examination reveals no clear-cut loss of sensation to pinprick over any nerve root distribution, and the triceps, biceps, and periosteoradial reflexes are normal. There is also no loss in muscle power. These findings distinguish the condition from a ruptured intervertebral disc, which ordinarily shows reflex change and sensory diminution in the upper extremity. Diagnosis is confirmed by myelography, which should not be performed unless diagnosis is in doubt.

Treatment consists of head-halter traction, with the patient at bed rest, for two to three weeks. Vitamin B_{12} also aids in controlling the pain in the upper extremity. If the patient prefers not to have head-halter traction and bed rest, an alternative treatment consisting of a plaster cast for the neck or a cervical brace may be used. It is also possible for the patient to set up a head-halter traction apparatus in the home in such a way that traction is exerted while he sits in a chair. Such a patient wears a cervical brace during the day, uses head-halter traction at home in the evening, and is in head-halter traction while in bed at night.

Hypertrophic Arthritis With Traumatic Radiculitis

A patient with hypertrophic changes in the neck may not have any difficulty until an injury is sustained. Following trauma, however, he usually complains of pain in the neck, with rather severe radicular pains in the upper extremity. Treatment is exceedingly difficult, and symptomatic relief is slow and sometimes never complete. The x-ray pictures help in distinguishing the condition from other conditions which produce neck and arm pain following injury, such as a ruptured intervertebral disc and simple muscle strain with traumatic radiculitis The x-ray pictures show especially not only the roughened vertebral body, but also more particularly the narrowing of the foramina and the encroachment of hypertrophic spurs upon the foramina (Right and left oblique views should be taken) Clinically the cervical spine may show marked limitation of motion in most directions not only because of the hypertrophic changes per se, but also because of muscle spasm and pain Although the radicular component may be rather acute, it is unusual to find any real sensory changes, such as diminution of sensation to pinprick, overlying any given nerve root distribution. Also, the reflexes are ordinarily normal.

Conservative treatment of hypertrophic arthritis with traumatic radiculitis should be vigorous in order to bring about relief as rapidly as possible. If the process is not shortly brought under control, then the chance for recovery diminishes. Treatment consists of bed rest, head-halter traction for two to three weeks, and large doses of vitamin B_{12}. It is also possible to apply a plaster cast

particularly of the cervical spine, reveals limitation in the range of motion in the cervical spine due to two main causes, arthritic changes in the cervical spine per se and muscle spasm and pain elicited upon motion. The limitation in the range of motion in the cervical spine is usually asymmetrical; that is, there is more limitation on one side than on the other. Lateral inclination of the head toward the affected side is likely to increase the pain, as is oblique, posterior positioning of the head toward the affected side. In other words, motions which are likely to pinch the nerve roots at the foraminal exits are most likely to produce pain.



Fig 139.—Hypertrophic changes of the cervical spine. Note particularly the sharp spurs on the anterior aspect of the vertebral centra of C-5, C-6, and C-7.

The opposite motion of lateral inclination away from the affected side is likely to cause far less discomfort. Also, there are no clear-cut neurologic changes in the arm, either in sensitivity to pinprick or in the reflexes. The roentgenograms, which should include right and left oblique views as well as anteroposterior and lateral views, are the most help in diagnosis. They reveal the hypertrophic spurs on the vertebral bodies (Fig. 139) and the irregularity and narrowing of the intervertebral spaces. The most significant changes, however, are seen in the right and left oblique views of the cervical spine, which show

may even obliterate the radial pulse on the affected side. There usually is no sensory or reflex abnormality in the affected upper extremity. The diagnosis therefore depends, in the absence of findings of a cervical rib on x-ray pictures, upon the increase in symptoms and the diminution or obliteration of the radial pulse upon lateral positioning of the head away from the affected side and exertion of pressure downward upon the affected shoulder.

Conservative treatment is frequently successful and consists of shoulder exercises designed to enable the patient to carry the shoulders in a better upward and backward posture. Sometimes a light shoulder brace which holds the shoulders backward relieves pressure on the brachial plexus and brachial artery and therefore gives symptomatic relief. A program of exercises is the preferred treatment if relief can be obtained therefrom. If conservative treatment fails and if the symptoms are sufficiently pressing, resection of the cervical rib or section of the scalenus anticus muscle is possible. A cervical rib and scalenus anticus syndrome are distinguished from hypertrophic arthritis with radiculitis by the fact that they occur, in general, in a younger age group, by more or less negative x-ray findings, and by the fact that motion toward the affected shoulder is less likely to cause pain than motion away from the affected side.

Hypertrophic Arthritis With Radiculitis

While at times a patient may have hypertrophic change in the cervical spine and be asymptomatic until sustaining a whiplash injury (as previously described), the present discussion deals with hypertrophic change in the cervical spine with radiculitis which arises spontaneously and which is not associated with injury. The complaint in this circumstance is likely to be of rather considerable duration and ordinarily begins as pain localized in the neck, without radiation into the arm. Gradually associated complaints may develop which are recognized as referred and radicular pain. For example, it is common for the patient to complain first of neck pain and then of a "headache," which he localizes in the occipital region. He is often concerned with the fact that the occipital headache may indicate that he has hypertension. In addition to the neck and occipital pain, the patient may develop pain which radiates down along the border of the trapezius muscle to the point of the shoulder and, at times, into the upper arm, forearm, or hand. Sometimes the pain in the arm is sharp, shooting, and easily localized. Most often, however, the patient is unable to define the pain or its course very clearly, except to say that it is in the arm. It is not unusual for the pain to radiate into the chest, particularly into the precordium. This causes some confusion at times in the differential diagnosis between a cardiac condition and the actual underlying hypertrophic arthritis in the cervical spine with radiculitis. Therefore, if the history is of neck pain, which may be associated with occipital pain, precordial pain, or upper extremity pain, the possible diagnosis of hypertrophic arthritis in the cervical spine with radiculitis should be strongly considered. It is well to note whether the patient is in an age group in which hypertrophic change is likely. Examination probably reveals stigmas of hypertrophic change, such as deformities of the distal interphalangeal joints and Heberden's nodes. Further examination,

particularly of the cervical spine, reveals limitation in the range of motion in the cervical spine due to two main causes, arthritic changes in the cervical spine per se and muscle spasm and pain elicited upon motion. The limitation in the range of motion in the cervical spine is usually asymmetrical; that is, there is more limitation on one side than on the other. Lateral inclination of the head toward the affected side is likely to increase the pain, as is oblique, posterior positioning of the head toward the affected side. In other words, motions which are likely to pinch the nerve roots at the foraminal exits are most likely to pro-



Fig 139.—Hypertrophic changes of the cervical spine. Note particularly the sharp spurs on the anterior aspect of the vertebral centra of C-5, C-6, and C-7.

duce pain. The opposite motion of lateral inclination away from the affected side is likely to cause far less discomfort. Also, there are no clear-cut neurologic changes in the arm, either in sensitivity to pinprick or in the reflexes. The roentgenograms, which should include right and left oblique views as well as anteroposterior and lateral views, are the most help in diagnosis. They reveal the hypertrophic spurs on the vertebral bodies (Fig. 139) and the irregularity and narrowing of the intervertebral spaces. The most significant changes, however, are seen in the right and left oblique views of the cervical spine, which show

the hypertrophic spurs impinging upon the neural foramina. (Fig. 140.) It is easy to postulate under such circumstances that the nerve roots passing through the foramina might well be irritated, becoming swollen and edematous. Thus the pain either up over the occiput or down along the border of the trapezius and into the arm in various distributions is explained. Hypertrophic change with radiculitis is distinguished from scalenus anticus syndrome and cervical rib in the following manner.



Fig 140 —Oblique view of the cervical spine. Arrow indicates impingement of a bony spu on the foramen.

Hypertrophic arthritis with radiculitis occurs in an older age group and ordinarily shows the stigmas of hypertrophic arthritis elsewhere in the body, such as in the distal interphalangeal joints of the fingers. Furthermore, in both scalenus anticus and cervical rib, lateral inclination of the head away from the side with the pain is likely to aggravate the pain, whereas the reverse is true in hypertrophic arthritis with radiculitis (that is, inclination of the head toward the side with the pain is likely to increase the pain). Roentgenograms are characteristic of each condition, revealing the cervical rib in the one condition and the hypertrophic change in the other.

Several methods of conservative treatment are available. One consists of the application of a plaster cast to the neck, extending it up onto the lower jaw and down over the chest, both anteriorly and posteriorly. A cervical brace can be used, as can a Thomas collar. An excellent method of treatment consists of head-halter traction which can be applied with the patient at complete bed rest for two to four weeks or applied intermittently during the day and constantly during sleep at night. The administration of vitamin B_{12}, 25 mcg. three times a day, is useful in combatting the radicular pain. Deep heat in the form of diatheramy is also useful in controlling the discomfort. For patients with a moderate condition, the method which seems to be the most advisable under the most circumstances is head-halter traction used intermittently during the day and continuously at night. In patients with a severe degree of radicular pain, hospitalization and continuous traction are advisable.

Stiff Neck*

A common complaint is the so-called stiff neck. The patient usually states that he was either exposed to a draft of cold air (commonly from an air conditioning unit) or slept in a draft of cold air or in an awkward position. He complains that one side of his neck is painful and stiff, so that he cannot move the head in a normal fashion. In addition, he may state that in order to arise from a supine position, he must hold his head with his hands because of the severe pain. Inspection reveals that the head is held rigidly and slightly inclined somewhat toward the affected side. Examination reveals tenderness in the muscles laterally, particularly over the trapezius. Forward flexion is markedly limited and produces pain in the side and posterior aspect of the neck Lateral inclination away from the side with the pain may be impossible because of the pain and spasm Inclination of the head toward the side with the pain is more likely to give relief. The roentgenograms are negative.

Treatment consists of diatheramy and massage and of the administration of mephenesin to reduce the muscle spasm. Head traction is used in patients with a severe condition. Salicylates are helpful, and narcotic medication may be necessary.

Spasmodic Torticollis

Fortunately the practitioner very *rarely* encounters a patient who complains of pain in the neck associated with twitchings or motions of the head to the side. The word "fortunately" is used advisedly, inasmuch as spasmodic torticollis has an extremely poor prognosis. As the physician listens to the complaint of the patient, he will notice that the movements of the patient's head into the position of torticollis are in proportion to his nervous state.

*Some diagnose this condition as myositis or myofascitis, whereas others deny the existence of myositis in this connection. We confine ourselves to the complaint, the history, the examination, and the treatment.

In examination of such a patient, the physician can feel the spasmodic, intermittent, and powerful contractions of the trapezius and sternocleidomastoid muscles very readily. Any attempt by the physician to hold the patient's head steady is usually unsuccessful, inasmuch as the muscles which draw the head into the position of torticollis are more powerful than the physician's ability to stabilize the head. Roentgenograms of the cervical spine are negative. The etiology is unknown, although some believe that the condition is an intracranial irritative lesion of the nuclei supplying the spinal accessory nerve, which is the motor nerve to the upper portion of the trapezius and the sternocleidomastoid muscles. The condition is aggravated by emotional upset, and it appears that there is a large psychiatric element in the etiology.

Most methods of treatment, such as casts, braces, or traction, usually prove ineffective, and even section of the spinal accessory nerve many times fails to interrupt spasmodic torticollis. Psychotherapy and sedative drugs, such as phenobarbital, have also been used. The prognosis is very poor.

Chapter Eight

*Disturbances of the Shoulder in the Adult**

ANATOMY

Movement of the upper extremity upon the trunk depends not only on motion at the shoulder joint alone, but also on motion of the scapula, motion at the acromioclavicular joint and the sternoclavicular joint, and rotation of the clavicle in its longitudinal axis.†

Since the role of the various muscles engaged in movement of the upper extremity has long been misstated and misunderstood, it is well to review some of the salient anatomic facts. The deltoid muscle, arising from the clavicle and the spine of the scapula and covering the lateral aspect of the shoulder joint, inserts at about the midshaft of the humerus and acts in abduction of the arm. The short rotators, or the musculotendinous cuff, are composed of the subscapularis, the supraspinatus, the infraspinatus, and the teres minor muscles. These muscles insert on the humerus in the region of the greater and lesser tuberosities and are active in rotating the humerus and depressing the humeral head. The supraspinatus is important in abducting the arm.

Overlying the supraspinatus tendon and between it and the deltoid muscle and acromion process is the so-called subacrominal bursa, whose importance will be apparent later in the discussion. The glenoid is shallow and much of the depth needed for the humeral head comes from the fibrocartilaginous glenoid labrum. The glenohumeral joint obtains some stability from the long head of the biceps, which passes up the anterolateral aspect of the joint and attaches to the superior rim of the glenoid. The pectoralis major acts not only in forward flexion, but also, with the latissimus dorsi, in internal rotation. Motion of the scapula is controlled by the trapezius, the levator scapulae, the rhomboids, and the serratus anterior. Therefore, the shoulder joint is a loose articulation which

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*For a discussion of disturbances of the shoulder in childhood, see Chapter 1, Diseases or Affections in Childhood (page 101).

†For an understanding of the motion of the upper extremity [illegible] V. T., Saunders, J. B. deC. M., and Abbott [illegible] Bone & Joint Surg. 26:1, 1944. At least th[illegible] [illegible]ciated.

obtains much of its movement at the expense of its stability, depending on the surrounding muscles for what stability it does have.

During normal abduction of the arm, several actions occur simultaneously and successively. As abduction begins, both the deltoid and the supraspinatus are active and continue to be active throughout the entire range of abduction. At the time abduction is started, the scapula oscillates at first and then swings laterally. Furthermore, during the early part of abduction, the sternoclavicular joint allows motion. If abduction is continued, the humeral head is depressed more deeply into the glenoid by the short rotators, allowing more stability at the glenohumeral joint and giving greater purchasing power to the deltoid and supraspinatus. Also, during this middle portion of the range of abduction, the scapula, changing from a lateral path, moves in an arc anteriorly and rotates on its longitudinal axis. In the later stages of abduction (after the humeral head has been depressed, the scapula has been turned on its long axis and swung forward, and the sternoclavicular joint has passed through an arc of motion), the acromioclavicular joint contributes movement, and the clavicle rotates on its long axis. In fact, many of the actions described take place during the entire range of abduction. The order in which they are described simply indicates the time at which a given action is most obvious or greatest in magnitude. For example, the clavicle is probably rotating on its longitudinal axis from shortly after the beginning of abduction. However, its movement is most obvious and of greatest magnitude in the later stages. A rhythmic and smooth action is performed by a teamwork of many independent structures working simultaneously, with each structure at times playing a more important part in the action as a whole. It can be seen that abduction involves not only the supraspinatus and deltoid muscles, the glenohumeral joint, and the short rotators, but also the clavicle, the clavicular joints, the scapula, and the muscles controlling the scapula. Motion of the shoulder should be considered a trunk-extremity movement rather than an isolated movement.

EXAMINATION AND DIFFERENTIAL DIAGNOSIS

Differential diagnosis is aided by dividing the conditions of a painful shoulder into traumatic injuries and nontraumatic disorders. Traumatic injuries are discussed first.

If the complaint is of a painful shoulder immediately following an injury, the likely diagnoses are divided into conditions which are revealed on x-ray pictures (such as fractures) and conditions which are not revealed on x-ray pictures (such as complete or partial tear of the supraspinatus musculotendinous cuff.) If the history is of an injury to the shoulder, with resultant pain and disability of the shoulder and arm, the likely diagnoses include such conditions as fracture of the clavicle, acromioclavicular separation, dislocation of the shoulder, fracture of the neck of the humerus, or fracture of the humeral shaft.

If it is thought that some type of fracture or dislocation exists, examination begins with palpation of the clavicle The diagnosis of a fracture of the clavicle is ordinarily simple to make inasmuch as the bone is subcutaneous, and the fracture site is very tender to palpation. The fracture can many times be palpated

and false motion felt. The next area to consider is the region of the acromioclavicular joint. In separation of the acromioclavicular joint, a swelling or deformity at this small joint at the very top of the shoulder is usually quite obvious. (The difficulty in making this diagnosis lies in the fact that ordinarily the area is not examined, nor is the diagnosis thought of at all.) The outer end of the affected clavicle rides higher than the outer end of the unaffected clavicle. The patient experiences local tenderness directly over the acromioclavicular joint. In addition, downward pressure upon the body of the clavicle demonstrates that the dislocation or separation can be reduced to normal but that upon release of the pressure on the clavicle the separation recurs. Examination continues with inspection of the lateral contour of the affected shoulder, comparing it with that of the unaffected shoulder. In dislocation of the shoulder, the dislocated side is flatter than the normal side and does not have the rounded contour which is made by the humeral head in its normal position beneath the deltoid muscle. Palpation may reveal a hollow space just below the outer edge of the acromioclavicular joint and the acromion. In addition, it is possible to palpate the humeral head in its dislocated position anteriorly and somewhat in the region of the coracoid process lying beneath the pectoral muscles of the chest. If a fracture of the neck of the humerus is present, the lateral contour of the shoulder may be normal both to palpation and inspection, unlike a dislocated shoulder, but there will be a characteristic swelling of soft tissue anterior to the shoulder joint. This soft tissue swelling strongly suggests a fracture of the neck of the humerus, with or without displacement. If the examination is continued distally down the upper extremity for a short distance, it may be found that the disability does not lie within the shoulder itself but is due to a fracture of the shaft of the humerus. Under these circumstances, the tenderness is located distally on the arm rather than at the shoulder, and the arm is quite unstable. In the injuries described, the roentgenograms are of course positive, with the possible exception of an acromioclavicular separation. At times it is necessary to take special roentgenograms of an acromioclavicular separation in order to confirm the diagnosis. Ordinarily, however, clinical examination leaves no doubt that such a separation exists.

If clinical examination reveals no positive findings and if the roentgenograms are negative, the likely diagnosis probably is a tear of the supraspinatus cuff, either partial or complete, or a reflex sympathetic dystrophy. In the case of an acute, partial, or complete tear of the supraspinatus cuff, the diagnosis may be difficult to make until sometime after the injury. There will be the usual loss of active power of abduction, and there will be an area of tenderness situated lateral to the shoulder—in general, in the region of the greater tuberosity of the humerus.

In considering a diagnosis of reflex sympathetic dystrophy, the practitioner should note whether the patient complains of both shoulder and hand pain and whether the hand reveals changes such as coolness and redness or pallor and increased sweating.

The second large group of disturbances of the shoulder are those disorders which arise spontaneously, with pain and disability in the shoulder, and are not

due to traumatic injury. They include such conditions as acute calcific bursitis, subacute or chronic calcific bursitis, bursitis without calcification, tenosynovitis of the long head of the biceps, or frozen shoulder. Diagnosis in this group depends more upon the localization of tender areas and the loss of motion than upon findings on the roentgenograms.

TRAUMATIC INJURIES TO THE SHOULDER

Complaint	Likely Diagnoses	Page
Pain in shoulder and inability to move arm	(1) Fracture of clavicle.	296
	(2) Acromioclavicular separation	297
	(3) Dislocation of shoulder...	299
	(4) Rupture of rotator cuff tendon	301
	(5) Reflex sympathetic dystrophy..	302
	(6) Fracture of neck of humerus.	303
	(7) Fracture of shaft of humerus	305

Fracture of the Clavicle

In a fracture of the clavicle, the patient falls, injures the shoulder, and complains of pain in the shoulder which is aggravated or increased by movement of the arm. Diagnosis is ordinarily easy, since palpation of the clavicle in its subcutaneous position usually reveals a sharply localized area of tenderness, since the false motion of the two fragments usually is readily apparent on palpation, and since the swelling is ordinarily directly over the fracture site. The x-ray pictures, of course, reveal the fracture, which is frequently in the midportion of the clavicle and commonly angulated upward, so that the shoulder and distal portion of the clavicle droop downward. (Fig. 141.)

Fractures of the clavicle are notoriously difficult to treat, and there are a staggering number of suggested methods of treatment. The difficulty arises from the fact that the clavicle is the only bony structure attaching the shoulder girdle and upper extremity to the trunk. Therefore, the shoulder and arm tend to droop The main principles of therapy are directed at elevating the shoulder, maintaining it posteriorly, and preventing the fracture from angulating superiorly. Consequently, Conwell's adhesive strapping method is good. In this method four main strips of adhesive tape are used. The first strip is started on the anterosuperior aspect of the shoulder and is passed diagonally down the back. The second is passed from the anterior part of the chest over the fracture (which is padded with felt) and down the posterior part of the chest. The third is started on the forearm just distal to the flexed elbow and is passed upward parallel to the upper arm, over the clavicle, and down the back (The purpose of this is to elevate the shoulder.) The fourth is started on the back and is passed horizontally around the upper arm and over the forearm (which is held in flexion) and is ended on the anterior part of the chest. Thus, the entire upper extremity is immobilized.

Other procedures in the treatment of a fracture of the clavicle include a clavicular cross, a figure-of-eight bandage, open reduction, lateral traction with the patient in a recumbent position, and insertion of a Kirschner wire throughout the length of the medullary cavity. Any method which successfully elevates

the shoulder, maintains the shoulder posteriorly, and prevents upward angulation at the fracture site is a good method.

One of the complications in treatment of the condition is deformity. In a woman, a good cosmetic result is relatively important and must be kept in mind. The deformity most likely to result is upward and forward angulation at about the middle portion of the clavicle. Since the clavicle is largely subcutaneous, the deformity is readily apparent. However, it interferes relatively little with function of the upper extremity. The possibility of deformity is one of the reasons why open reduction or traction, with the patient in a recumbent position, is used occasionally in the treatment of women patients. A possible but unusual complication is perforation of the lungs by one of the fracture fragments.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for six to eight weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he may note that there is none.

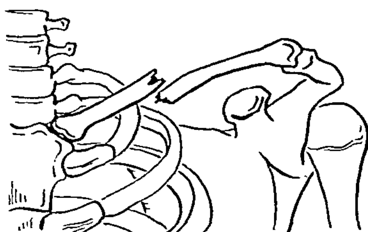


Fig. 141.—Fracture of the clavicle.

Acromioclavicular Separation

The difficulties in diagnosing an acromioclavicular separation result primarily from not considering such a diagnosis; next, from inadequate examination of the area; and last, upon occasions, from negative roentgenograms even in the presence of frank clinical acromioclavicular separation. The patient's complaints are pain in the shoulder and inability to move the arm. Clinical examination of the affected area reveals a more prominent bump at the tip and outer portion of the shoulder than on the normal side. The bump, of course, is due to upward protrusion of the dislocated end of the clavicle. The acromioclavicular joint is tender to palpation. Downward pressure upon the body of the clavicle causes the deformity at the end of the clavicle to disappear, while release of the pressure causes a recurrence of the deformity. The roentgenograms ordinarily reveal a separation of the acromioclavicular joint (Fig. 142) on the affected side when compared with the normal side. If the roentgenograms are equivocal, then views

of both acromioclavicular joints are made on a single film, with the patient in an upright position and holding several pounds of weight in each hand. Even when this procedure is followed, the roentgenograms can be negative although there is no doubt of the clinical diagnosis; however, this rarely happens.

Manipulative reduction is ordinarily easy, but maintaining the reduction is very difficult. A constant force pushing down on the clavicle and one pulling up on the arm are needed. Adhesive strapping, not unlike Conwell's method for the treatment of a fracture of the clavicle, can be used. However, there are many objections to adhesive strapping: the dislocation recurs easily since the adhesive is inadequate to hold the reduction and the skin is likely to break down, especially since this method requires a long time for healing.

In another method used in maintaining reduction a cast is applied around the chest, incorporating the affected arm held at the side of the body. A strap is then inserted beneath the cast and over the clavicle. As the strap is tightened, the clavicle is depressed and the cast is elevated; thus an upward thrust on the

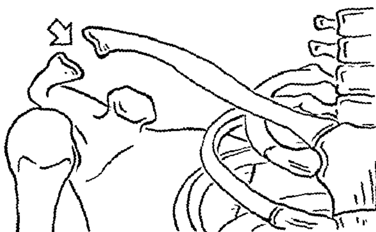


Fig. 142 —Acromioclavicular separation.

affected (and incorporated) arm is exerted. A warning should be expressed that pressure over the clavicle may cause a pressure sore.

As explained under Anatomy, the acromioclavicular joint is of importance in abduction of the arm. Therefore, we believe it unwise to excise, fuse, or permanently transfix the acromioclavicular joint if it can be avoided. A fusion limits the upper ranges of abduction However, in case it is impossible to reduce the dislocation and to maintain the reduction, operative intervention is indicated. In operative intervention, it is possible to insert a screw from the clavicle through the joint into the acromion, to wire the joint, to transfix the joint with a Kirschner wire, or to lash the joint down with fascial strips If a Kirschner wire is used, it may be inserted through the skin and then through the joint, in such a manner that it can be pulled out later after the ligaments have healed.

At times a recurrent dislocation of the acromioclavicular joint is encountered. Surgical reconstruction of the coracoclavicular ligaments can be used in treatment of this condition. It is also possible to excise the distal end of the clavicle.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for six to eight weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he should note that recurrence is common and that there may be an interference in the ability to abduct the shoulder.

Dislocation of the Shoulder

Due to the fact that the shoulder joint is unstable and must depend upon a musculotendinous cone for the stability it does have, dislocation at the joint is common. In this condition the head of the humerus passes through the capsule and comes to lie anterior to the glenoid (so-called subcoracoid dislocation), and the patient complains of pain and inability to move the arm. Dislocation characteristically occurs when the patient falls with the upper arm in wide ab-



Fig. 143.—Subcoracoid dislocation of the shoulder.

duction. Examination reveals a hollow space where the head of the humerus is normally palpable on the rounded, lateral aspect of the shoulder. It is possible to palpate the head of the humerus in the axilla. The distal end of the clavicle projects laterally, and thus the contour of the shoulder is altered from its rounded appearance to almost a right angle. X-rays pictures reveal the dislocation. (Fig. 143.)

There are many methods of reducing dislocation of the shoulder, but only three are described here. (1) With the patient under anesthesia, his upper arm is grasped just above the elbow by one hand of the operator. The operator's other hand is placed on the medial side of the patient's upper arm proximally and nearly as high as the axilla. Traction is exerted, with the humerus in

of both acromioclavicular joints are made on a single film, with the patient in an upright position and holding several pounds of weight in each hand. Even when this procedure is followed, the roentgenograms can be negative although there is no doubt of the clinical diagnosis; however, this rarely happens.

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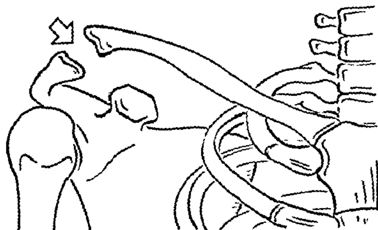


Fig. 142 —Acromioclavicular separation.

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some abduction, and a steady force is exerted laterally by the hand on the medial aspect of the patient's upper arm. More often than not, the method is successful. If it fails, the Kocher maneuver is performed. (2) The Kocher maneuver, which will usually reduce the dislocation, is performed as follows. With the patient's elbow at a right angle and with the forearm and elbow grasped by the operator, traction is exerted in moderate abduction of the upper arm. The humerus is then put into external rotation. The elbow is brought to the patient's side and eventually is carried medially over the chest to the midline. Meanwhile, external rotation of the humerus is still maintained. Finally, the humerus is rotated internally while the patient's hand is simultaneously placed on the unaffected shoulder. The Kocher maneuver depends for its success upon opening the rent in the joint capsule by external rotation and by levering the head of the humerus laterally, using the humeral neck and the ribs as a fulcrum. The danger in this maneuver lies in the possibility of fracturing either the neck of the humerus or the ribs or of injuring the brachial plexus. (3) In this method, reduction is accomplished without using anesthesia provided that the operator is especially experienced, provided that he has gained the patient's confidence, and provided that the patient is a muscular person accustomed to relaxing the muscles upon request. The patient's arm and forearm are grasped by the operator and gradually the arm is abducted at the shoulder until it is in a completely elevated position. Then external rotation is carried out gradually. Upon completion of the maneuver, the patient's arm will be in such a position that it appears he is about to place his elbow behind his head. Often in this position the dislocation has already been reduced without the knowledge of either the patient or the physician. At other times, however, it is necessary to exert a slight amount of gentle pressure upward into the axilla to bring about reduction; a very slight thud may be felt as reduction occurs. It must be emphasized that this method of reduction should not be undertaken if the patient is anxious or nervous or if the physician cannot gain the patient's complete confidence.

In all three of the procedures just described, the arm is immobilized by placing a pad in the axilla and by strapping the arm and the forearm to the chest, with the patient's hand placed on the unaffected shoulder and the elbow in flexion. This position is maintained for two weeks, after which gentle exercises are started.

A certain number of patients who sustain one dislocation will suffer a second. Sometimes the shoulder joint becomes so unstable that these recurrent dislocations occur while the patient is sleeping. A plausible explanation of why some patients suffer recurrent dislocation while others do not suggests that the original dislocation is different in those patients who eventually suffer recurrent dislocation. In such patients it is postulated that the head of the humerus perforated the capsule near the glenoid labrum, which itself was torn loose from the bone of the scapula, and, furthermore, there was an erosion or defect in the head of the humerus posteriorly so that stability is lost in certain positions of the arm and the chances of dislocation are enhanced. In those patients who do *not* suffer recurrent dislocation, it is postulated that the glenoid labrum was not torn loose, that there was no defect on the posterior aspect of the humeral head, and that the perforation of the capsule occurred more distally. At the time

an original dislocation occurs it usually is impossible to predict whether or not a recurrent dislocation of the shoulder will take place.

Many operative measures have been suggested for the treatment of recurrent dislocation. We believe that the Bankart procedure attacks the fundamental pathologic features and is therefore the soundest operation. In this procedure the shoulder joint is approached anteriorly, the anterior rim of the glenoid is refreshed, and the anterior capsule and glenoid labrum are attached to the rim of the glenoid by sutures inserted through holes drilled in the bone. In this manner at least some of the mechanical abnormalities which allow recurrent dislocation are corrected, a new, strong soft tissue bulwark against dislocation is created. Many other procedures re-enforcing the anterior capsule accomplish the same purpose.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for four to six weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he should note that the patient may lose the upper ranges of abduction and forward elevation in the shoulder and that recurrent dislocation may supervene.

Rupture of the Rotator Cuff Tendon

In a rupture of the supraspinatus tendon, unlike the shoulder disturbances discussed thus for, the x-ray pictures are negative and therefore do not aid in diagnosis, which must be made from clinical observation during examination of the shoulder. However, as in the other conditions, the patient complains of pain in the shoulder and inability to move the arm.

It will be recalled that underlying the deltoid muscle is a musculotendinous cuff which attaches to the greater tuberosity of the humerus. The cuff is made up of the subcapsularis, the supraspinatus, the infraspinatus, and the teres minor muscles. The supraspinatus aids the deltoid muscle in abduction of the arm at the shoulder joint.

Rupture of the rotator cuff occurs as a result of trauma, especially in men, and ordinarily after 40 years of age. The common cause of a rupture of the rotator cuff is a fall on an outstretched arm. Since rupture occurs mainly in persons over 40 years of age, it has been suggested that certain degenerative changes within the tendon are a prerequisite of the condition. Various degrees of tear from a small rent to a complete avulsion of the musculotendinous cuff are, of course, possible.

The patient often states that following injury he is unable to lift the arm beyond a relatively small arc (about 30 to 40 degrees from the side of the body) because of pain and weakness in the shoulder. Passively, the examiner can abduct the arm to its full extent with little or no pain to the patient. If he then releases his support and directs the patient to lower the arm from full abduction, the patient lowers the arm to about 70 degrees of abduction, at which position there is a sudden uncontrollable dropping of the arm to a much lower position before control can be gained once more. This is called the "drop" sign. If the condition has persisted for a few months before the patient seeks advice, it can be noticed that in some patients there is a definite atrophy of the body of the supra-

spinatus muscle or even of both the supraspinatus and infraspinatus muscles. Roentgenograms are negative as a rule, but they may reveal simple bone atrophy due to disuse and eburnation of the articular tip of the greater tuberosity.

In a good number of patients with an *acute* rupture of the rotator cuff, conservative treatment with an airplane splint produces a satisfactory shoulder. Nevertheless, suture of the torn tendon is frequently necessary to obtain adequate function. During the operation, after retraction of the deltoid muscle, exploration of the musculotendinous cuff is carried out by direct vision. If a rupture is present, one can see the interior of the shoulder joint. (Fig. 144). It is not possible to see the interior of the shoulder joint after retraction of the deltoid if



Fig 144 —Tear of the rotator cuff of the shoulder as visualized at operation.

the musculotendinous cuff is intact. The edges of the torn tendon are refreshed and sutured.

Physical therapy following operative repair is important to full recovery but should not be started until three weeks following the operation.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for three months and partially disabled for an additional six weeks.

Reflex Sympathetic Dystrophy

Upon occasion a patient sustains an injury of rather small magnitude and then complains of pain in the shoulder and hand which is out of all proportion

to the violence of the injury per se. Roentgenograms of the shoulder are not helpful but may show atrophy. Examination of the shoulder reveals simply that almost all movement, passive or active, is painful and causes more severe pain than would be expected. Examination of the hand may reveal it to be cold and sweating, sometimes with an apparent pallor but at others with an unhealthy rubor to the skin and edema.

If reflex sympathetic dystrophy (painful state, hand-shoulder syndrome) is suspected, temperature studies, carried out on the affected hand and compared with the unaffected hand, may reveal a diminution in temperature in the affected hand. Cervical sympathetic block, using Novocain, relieves the pain in the shoulder and hand, improves the color and circulation of the hand, and stops the sweating of the hand. Cervical sympathetic block may be performed either as a diagnostic measure or as a means of treatment. After one block the patient may obtain relief for twenty-four to forty-eight hours only. If this occurs a series of sympathetic blocks, spaced progressively farther apart, may bring the process under control, or dorsal sympathectomy can be considered. Consultation should be held relatively early in such cases, inasmuch as the sooner the pain is interrupted, the better the prognosis for recovery.

Fracture of the Neck of the Humerus

A fracture of the surgical neck of the humerus often presents an obvious clinical sign. If a rather sharply outlined area of swelling localized to the anterior aspect of the shoulder is present, a fracture of the surgical neck of the humerus is likely. (The portion of the humerus just distal to the insertion of the capsule of the shoulder joint is the surgical neck of the humerus and the portion just proximal to the capsule is the anatomic neck.) The presenting complaints are pain in the shoulder and inability to move the arm. Fractures through the surgical neck are common and are usually transverse. There are several types. In children the fracture normally occurs through the epiphyseal line, and the shaft is ordinarily completely displaced from contact with the head. In young adults the fracture through the surgical neck is also ordinarily displaced so that the shaft is not in contact with the head. (Fig. 145.) In the older age groups, however, very often there is no displacement between the shaft and the head (Fig. 146), or, if there is some displacement, the shaft still has not completely lost contact with the humeral head. The difference in the type of fracture sustained in the various age groups may be due to the severity of the injury. In children and young adults the violence is often relatively severe, such as a fall from a considerable height. In the older age groups, the violence is less severe, such as tripping over a rug and falling the short distance to the floor. Therefore, it is to be expected that complete displacement of the shaft from the head would occur in the younger age groups but not in the older.

Epiphyseal Separation.—Since a growing center of bone is involved in this type of fracture, a good reduction should be obtained. Sometimes manipulation is successful in achieving reduction. We suggest that the manipulation be performed by wide and relatively forceful abduction of the arm well beyond a position of 90 degrees. If the manipulation is successful, a shoulder spica is



Fig. 145.—Fracture of the surgical neck of the humerus, with displacement, in a young patient.



Fig. 146.—Fracture of the surgical neck of the humerus, without displacement, in an elderly person.

then applied. However, many times manipulation fails to achieve reduction; under such circumstances, open reduction and internal fixation are carried out. Only one attempt at closed reduction should be made, since repeated attempts may injure the epiphyseal plate. If open reduction and internal fixation are used, the arm is frequently strapped to the side rather than put in a cast.

Transverse Fracture With Complete Displacement.—Experience has shown that in a fracture with complete displacement in a young adult very often neither manipulation nor traction is successful in achieving reduction. Therefore an attempt at closed reduction should be made, but the physician should be prepared to proceed with open reduction during the same operation in case manipulation fails.

If a completely displaced fracture of the surgical neck occurs in an elderly patient (an unusual situation) and if the patient does not seem to be a good operative risk, it is well to attempt manipulative reduction with the patient under anesthesia. If the manipulation fails, a hanging cast can be tried. A hanging cast is suggested in this circumstance because traction and open reduction both carry certain dangers for the elderly patient.

Fracture of the Surgical Neck Without Displacement.—In the group over 60 years of age, the problem is quite different. Usually there is little displacement, and the shaft remains in contact with the head (instead of being completely displaced), but comminution is frequently associated with the condition. Furthermore, immobilization of the shoulder in an elderly patient often leads to a very stiff, disabled joint (which is not so common in younger patients).

Open reduction in an older person frequently is too severe a procedure, and often the results are more disappointing than the results of conservative therapy. Consequently, treatment of this fracture consists simply of applying an axillary pad and a wrist sling from around the neck. A special form of physical therapy called "relaxed motion" is started in forty-eight hours after injury. This treatment avoids the severity of open reduction and maintains motion at the shoulder joint by early physical therapy. Motion is considered to be more important than a certain degree of deformity under these circumstances. Relaxed motion which depends on gravity for movement, is neither passive nor active motion, and is carried out as follows The wrist sling is released, and the entire extremity is allowed to dangle loosely. The patient then bends forward at the hips, allowing the arm to hang freely downward, and sways the body so that the arm swings in a circular motion, but he does not exercise muscle control. In this manner, motion is maintained at the shoulder joint.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for twelve to fourteen weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he should note that there might be a loss in the upper range of abduction and in external and internal rotation.

Fracture of the Shaft of the Humerus

A fracture of the shaft of the humerus presents the same difficulties that are encountered in a fracture of the shaft of the femur or of the shaft of the tibia

if the fibula is also injured; in other words, those encountered in a fracture of the shaft of a single long bone. In this case, the type of fracture plays an especially large part in determining the treatment of choice.

The presenting complaints in fracture of the shaft of the humerus are pain in the shoulder and inability to move the arm. In managing such a fracture, two factors especially should be kept in mind: the possibility of injury to the radial nerve and the possibility of nonunion.

It will be recalled that the radial nerve winds around the posterior aspect of the humerus to reach the anterior surface distally just above the elbow. During much of its course it very closely approximates the humeral shaft. Consequently, a fracture of the shaft may lacerate this nerve either partially or completely or edema or a hematoma associated with the fracture may compress it. Moreover, in the healing process of a fracture of the humeral shaft, the radial nerve may become enclosed in exuberant callus and thus become constricted. Since the radial nerve supplies motor impulses to the extensor muscles of the wrist and hand, it is well to test the patient's ability to extend the wrist when a fracture of the shaft of the humerus is suspected. Very often a wristdrop is present which may be due simply to edema and hematoma rather than to laceration of the nerve. Consequently, the simple finding of a wristdrop alone is not sufficient indication for surgical exploration. The physician is justified in waiting about two weeks for indication of a beginning return of nerve function. If there is some return, *further observation is indicated. If, however, there is no* return of function within two weeks following injury, exploration of the radial nerve should be considered seriously.

As has been stated previously, the possibility of nonunion should not be overlooked. While the incidence of nonunion is especially high in fractures at the junction of the upper two thirds and distal one third of the shaft, risk of nonunion is also encountered in midshaft fractures. Good approximation of the fracture fragments probably aids union, although nonunion can develop in fractures which are perfectly aligned.

A discussion of several types of fractures of the shaft of the humerus commonly seen is now presented.

Transverse Fracture.—A transverse fracture is usually present if there is no appreciable displacement, angulation, or overriding of the fragments; that is, there is end-on apposition of the fragments. Generally, if there is no displacement, the immediate application of a cast will probably prevent the fragments from overriding. Therefore, many times the only treatment consists of applying a shoulder spica, provided the fracture is transverse and there is end-on apposition of the fragments (not completely displaced from one another). Weekly x-ray pictures for three weeks will show whether alignment and length have been maintained.

Oblique or Spiral-Oblique Fracture.—An oblique or spiral-oblique fracture of a single long bone lacks the stability at the fracture site which a transverse fracture has. Therefore, overriding is common and must be combatted continuously until adequate healing occurs Treatment by the immediate application of a cast alone is ordinarily inadequate because overriding occurs be-

neath the cast even if a good reduction is obtained at the time the cast is applied. The fracture is best treated by traction for four to six weeks (to allow healing to begin) and then by application of a shoulder spica until healing is complete.

Comminuted Fractures.—There are two main types of comminuted fractures of the humeral shaft. In one type a great many small fragments constitute the comminution. In such a situation traction is perhaps the best method of treatment, since no stability at the fracture site can be hoped for by either ma-



Fig 147.—Comminuted fracture of the shaft of the humerus in which there are two large free and uncontrollable central fragments.

nipulation or open reduction. In the other type, one relatively large (Fig. 147) fragment is free and constitutes the comminution; that is, there is one large, free, central fragment in between two main fragments of the shaft. In this circumstance, such a free fragment, being reasonably large, can enhance the risk of nonunion and is impossible to control from the standpoint of positioning it or achieving and maintaining reduction. Therefore, open reduction is often the treatment of choice provided that the comminuted fragment is large enough to be a factor in healing and large enough that control can be achieved.

A hanging cast is sometimes used in the treatment of a fracture of the humeral shaft. This is a circular cast which is applied from well up on the upper arm, down over the elbow (which is at 90 degrees of flexion) and forearm (which is in midpronation) to the wrist. The portion of the cast over the forearm is made especially thick and heavy. A loop (through which the cravat is threaded) is incorporated into the cast on the forearm about one third of the distance up the forearm from the wrist. The cravat passes around the neck so that the cast hangs, thus exerting traction on the fracture site. The patient is advised to allow the cast to hang freely and to sleep in a semiupright position. Certain criticisms of the hanging cast have been pointed out. It has been found that a patient tends to rest the elbow on a convenient table and thus, in effect, destroys the traction. Also, when sleeping, it is difficult for the patient to maintain a position which ensures the hanging action of the cast. Furthermore, at least theoretically, the hanging cast violates the principle of immobilizing the joints above and below the fracture. One of the reasons for applying a shoulder spica with 90 degrees of abduction or of using traction with the shoulder at 90 degrees is to maintain active abduction at the shoulder. The hanging cast keeps the arm at the side of the body, and the patient may temporarily lose his ability to abduct the upper arm actively. Nevertheless, many believe this method to be very satisfactory.

Open reduction of a fracture of the shaft of the humerus is occasionally indicated. Since the midshaft (or a little more distal site) is a frequent site of nonunion, reasonably good apposition and aligment of fragments are needed to prevent this complication. Consequently, if a satisfactory position is not obtained by using manipulative measures or traction, open reduction is indicated. It is also indicated if it is believed that the radial nerve is lacerated.

In filling out an insurance form, the practitioner should estimate the healing time at from seven to twelve weeks, total disability of the patient at eighteen to twenty weeks, and partial disability at four to six additional weeks. Under "Anticipated Loss" he should note that there may be radial nerve injury, with a transient or permanent wristdrop, and nonunion and its attendant disabilities.

NONTRAUMATIC DISORDERS OF THE SHOULDER

Complaint	Likely Diagnoses	Page
Spontaneous (nontraumatic) pain in shoulder and inability to use shoulder	(1) Acute calcific bursitis	309
	(2) Subacute or chronic calcific bursitis	311
	(3) Acute bursitis without calcification	311
	(4) Tenosynovitis of long head of biceps	312
	(5) Frozen shoulder	313

There is a group of complaints and disorders of the shoulder which are spontaneous and not associated with injury. Some of the common conditions included in this group are acute calcific bursitis, subacute or chronic calcific bursitis, bursitis without calcification, tenosynovitis of the long head of the biceps, and frozen shoulder. In these conditions the roentgenograms are of help only in establishing whether or not a calcific deposit is present in the shoulder. Therefore, diagnosis depends largely on the findings revealed by clinical examination.

Acute Calcific Bursitis

In acute calcific bursitis, the patient complains of a sharp, severe compelling pain within the shoulder which at times radiates down the arm into the hand in a diffuse and poorly localized manner. Frequently the pain has its onset in the middle of the night and is so severe that it interferes with sleep. The patient further complains that he cannot move the shoulder at all without severe, excruciating pain. Examination reveals that the patient is likely to hug the upper arm closely to his side and avoid any movement of the shoulder joint. He has great difficulty in removing clothing from the shoulder. Just lateral to the acromioclavicular joint there is usually a spot of exquisite tenderness to palpation. Even if the practitioner uses a very gentle touch, the patient is able to localize



Fig. 148.—Calcific deposit in the shoulder.

the area of tenderness as sharply as other patients are able to localize the tenderness of a boil. Active abduction cannot be performed because of the pain, which is due to the pinching of the inflamed bursa between the acromion and the humerus as abduction is carried out. Passive abduction is likewise impossible because of the pain. Also, external rotation of the humerus with the arm at the side is ordinarily painful. Roentgenograms may show a mass of calcific material in either the bursa or the supraspinatus tendon or in both. (Fig. 148.) The term peritendinitis calcarea, as well as calcific bursitis, is frequently used to designate either of these conditions.

It is not entirely clear what forces are responsible for the presence of the calcium in the tendon or what causes its appearance in the bursa. Some have suggested that the calcium is laid down in the supraspinatus tendon as a result

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a normal range of motion in the shoulder joint. If he does not, consultation should be held to consider the advisability of instituting physical therapy to avoid a stiff shoulder joint.

Subacute or Chronic Calcific Bursitis

A patient with a calcium deposit in the supraspinatus cuff of the shoulder may have no symptoms whatsoever for years. The calcification may be discovered as an incidental finding. At other times, however, a patient gives a history of a long-standing, gnawing, nagging, dull ache in the shoulder which is aggravated by changes in the weather and is somewhat troublesome. Examination reveals no particular spot of acute tenderness to palpation, although there may be one spot over the greater tuberosity of the humerus which might possibly be somewhat more tender than other areas. Both active and passive range of motion is normal, although the patient may experience some slight discomfort, particularly at 90 degrees of abduction. That is, the patient complains of a "catch" in the shoulder at 90 degrees of abduction, both in elevating the shoulder beyond 90 degrees and in resuming a normal position at the side of the body. The discomfort disappears when a higher range of elevation is reached.

The roentgenograms reveal a calcific deposit, confirming the diagnosis of subacute or chronic calcific bursitis of the shoulder.

Treatment in subacute or chronic calcific bursitis is much different from that in acute calcific bursitis. Neither the subacute nor chronic type is amenable to the injection of Novocain and Hydrocortone. Nor is x-ray therapy likely to give relief. At times diathermy gives comfort for a period of time. However, the nagging, dull, annoying pain is likely to recur. The best treatment is probably surgical excision of the calcific mass and portions of the underlying degenerated tendon. Operative exposure is made through the deltoid muscle, and the supraspinatus tendon and the accompanying musculotendinous cuff are exposed. The surface of the supraspinatus tendon may be found to be elevated in one particular area and the surrounding surface inflamed. Incision of the elevated portion should reveal a collection of firmly packed, crumbly, dry, calcific or chalklike material. This deposit should be curetted.

Following surgical excision of the calcific mass, it is important to institute physical therapy after most of the pain subsides to achieve movement in the shoulder.

Acute Bursitis Without Calcification

It is unusual but nonetheless possible for a patient to present with a condition which, by its history and complaint (sharp, severe, compelling, spontaneous pain in the shoulder which frequently begins in the middle of the night and is severe enough to prevent motion of the shoulder joint) is the same as acute calcific bursitis of the shoulder. The roentgenograms are negative, but the clinical examination reveals an area of exquisite tenderness just lateral to the acromioclavicular joint. Passive or active abduction or rotation is impossible because of the pain. Under these circumstances it is particularly important to distinguish

of degenerative change within the tendon. Then, for some reason not yet apparent, it bursts forth into the subacromial bursa to produce essentially chemical irritative bursitis. Not every patient with clear-cut clinical findings of subacromial bursitis has *calcium* within either the bursa or the supraspinatus tendon. Bursitis without calcification is quite possible.

Treatment is directed at decompressing the inflamed bursa. A convenient method of accomplishing this is as follows. After anesthetizing the area with Novocain, an aspirating needle is inserted into the subacromial bursa. The chalky solution (calcium from the bursa) is aspirated, multiple needle punctures are made through the bursa, and the surrounding area is infiltrated with about 10 c.c. of Novocain and 2 c.c. of Hydrocortone. Characteristically, the pain immediately subsides, completely and dramatically, and full use of the shoulder is possible. Within the next forty-eight hours an exacerbation of pain is experienced, but complete relief occurs in the majority of patients thereafter. In some patients about one week is required for the pain to subside. Multiple needle punctures are made not only to decompress the sac but also to obliterate it by causing adhesions between the scarified walls. The roentgenograms sometimes show that all evidence of calcium has disappeared within six to nine months after the multiple needle punctures are made.

X-ray therapy is an alternate method of treatment. Usually five or six treatments are given. The patient should be advised that often there is a flare-up of pain following the first x-ray exposure. Thereafter, the pain and disability are likely to disappear.

An important feature in the management of the condition is the application of ice to the shoulder. Many advise applying heat during the acute stage, but we believe such treatment often aggravates the pain. Ice bags applied continuously appear to alleviate most of the pain. Ice is especially useful in the treatment of night pain, which is a very frequent complaint.

It should be emphasized that the treatment just described applies to *acute* calcific burisits—*not* subacute calcific bursitis or chronic calcific bursitis.

In essence, the diagnosis of acute calcific bursitis depends on the following: (1) a history of a sudden onset of acute, compelling pain within the shoulder, (2) a sharply localized area of exquisite tenderness lateral to the acromioclavicular joint on the shoulder, (3) the inability to abduct the shoulder joint, either passively or actively, or to rotate the shoulder joint, and (4) roentgenograms revealing calcification in the vicinity of either the subacromial bursa or the supraspinatus tendon Disability and acuity of the pain are affected but little by the size of the calcification, a very small calcification is at times present in a most acute clinical condition Treatment consists of multiple needle punctures and the injection of Novocain and Hydrocortone, together with the continuous application of ice bags, and the administration of a narcotic to ease the pain. An alternative treatment consists of x-ray therapy which is also followed by the application of an ice bag and the administration of a narcotic for pain.

Close observation of the motion of the shoulder following treatment by either method should be made. In a week to ten days the patient should have

Conservative treatment is of two general types. In one method the shoulder is placed at rest, either by strapping it or by using a sling for a few days until the acute symptoms subside. The local application of heat appears to be of benefit. We caution against immobilizing the shoulder for too long a period, since stiffness may occur. Alternative treatment consists of the injection of Novocain and Hydrocortone along the course of the long head of the biceps in an attempt to cause the process to subside rather rapidly. This treatment is used particularly if the pain can be localized to a small area.

The practioner is warned that tenosynovitis of the long head of the biceps may progress to frozen shoulder, which is quite difficult to treat and is rather disabling over a long period of time.

Frozen Shoulder

There is a disability of the shoulder which is called variously frozen shoulder, chronic adhesive capsulitis, and periarthritis. Clinically, the patient, who is between 40 and 60 years of age, complains of pain and severe limitation in movement of the shoulder. Examination reveals that active abduction is limited to an arc of only 30 to 50 degrees from the side of the body. Furthermore, there is little, if any, internal or external rotation. The scapula moves en bloc with the humerus through whatever arc the latter is capable of. Passive and active motion are also quite limited. Therefore, it is apparent that the restricted activity is due to adhesions between the humerus and the scapula. The roentgenograms do not aid in making the diagnosis, since they are either negative or at most reveal a simple bone atrophy due to disuse—a nonspecific finding.

Depending upon the severity of the process, conservative or more radical therapy is indicated. Sometimes physical therapy, consisting of stretching and graded exercises, enables the patient to achieve full use of the shoulder. Manipulation, with the patient under anesthesia, to break up the adhesions is used at times. If manipulation is done, the various steps should be performed slowly and deliberately, and nothing more than gravity force should be used to achieve both internal and external rotation, since it is easy to fracture the proximal shaft of the humerus under these conditions. During the postoperative period, the patient experiences a great deal of pain in the shoulder, and heavy sedation is required. Emphasis is placed upon the extreme severity of the pain which occurs following manipulation under anesthesis. We prefer to avoid the method if possible. In recent years cortisone has been very helpful in controlling the pain.

Physical therapy is begun after the acute pain subsides. The patient is taught exercises for achieving abduction and internal and external rotation. There is a strong tendency for the stiffness to recur, and continual vigilance to prevent it is necessary for sometime afterward.

between bursitis without calcification, tenosynovitis of the long head of the biceps, and frozen shoulder.

In tenosynovitis of the long head of the biceps, the tenderness is sharply localized over the bicipital sulcus. Furthermore, the so-called supination sign is likely to be positive. This sign is elicited in the following manner. The patient is directed to hold the upper arm against the side of the body and to flex the elbow at a right angle. He then attempts to supinate the forearm against the resistance offered by the examiner. In such a motion the biceps is used as a supinator and the long head of the biceps is made taut. If the patient complains of an exacerbation of pain anterior to the shoulder and overlying the bicipital sulcus the sign is positive. In acute bursitis without calcification the sign is negative. In frozen shoulder the complaint is of longer standing than it is in acute bursitis without calcification or in tenosynovitis and the patient is more likely to complain of stiffness of the shoulder than of pain. While the roentgenograms are negative in all three conditions, nonetheless it is possible to demonstrate that the scapula and humerus do not move freely, except for a few degrees in frozen shoulder. If the pain in acute bursitis without calcification is great enough, the loss of motion in the shoulder may not be easily distinguished from that in frozen shoulder. However, frozen shoulder is very likely to lack the sharply localized area of tenderness on the lateral aspect of the shoulder which is present in acute bursitis without calcification.

In the treatment of acute bursitis without calcification generous amounts of Novocain and Hydrocortone are injected into the area of tenderness. As in acute calcific bursitis, an ice bag should be applied to the affected area, and heat should be avoided. There is likely to be a flare-up of pain following the injection, as in acute calcific bursitis, and narcotic medication may be necessary to control the pain. If the pain is not relieved within seven to ten days or if movement is not normal within this period, consultation should be held.

Tenosynovitis of the Long Head of the Biceps

If a patient complains of pain in the shoulder which is not associated with injury and in which the x-ray pictures are negative, the likely diagnoses include acute bursitis without calcification, tenosynovitis of the long head of the biceps, and frozen shoulder. Usually, in tenosynovitis of the long head of the biceps, the pain is more anterior than in acute bursitis without calcification. Examination of the shoulder may reveal tenderness to palpation over the bicipital sulcus. This differs from the tenderness in subacromial bursitis without calcification in that in the latter the tenderness is smaller in area and is situated just lateral to the acromioclavicular joint In tenosynovitis, movement in the shoulder is likely to be freer than in frozen shoulder. The supination sign should be sought and is elicited in the following manner. With the arm at the side and with the elbow at 90 degrees of flexion, the patient attempts to supinate the forearm against the resistance supplied by the examiner. This produces pain along the long head of the biceps, which the patient locates in the anterior aspect of the shoulder joint.

Conservative treatment is of two general types. In one method the shoulder is placed at rest, either by strapping it or by using a sling for a few days until the acute symptoms subside. The local application of heat appears to be of benefit. We caution against immobilizing the shoulder for too long a period, since stiffness may occur. Alternative treatment consists of the injection of Novocain and Hydrocortone along the course of the long head of the biceps in an attempt to cause the process to subside rather rapidly. This treatment is used particularly if the pain can be localized to a small area.

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Chapter Nine

*Disturbances of the Forearm and Elbow in the Adult**

In the forearm and elbow, complaints due to traumatic injury and the result of injury are more common than those due to nontraumatic disorders which arise without antecedent trauma. It is necessary to keep in mind a rather large number of possible conditions which can arise as a result of trauma to the forearm and elbow. These are fractures of either the radial shaft or the ulnar shaft independently, fractures of both the radius and ulna, fractures of the head of the radius, dislocation of the elbow, avulsion fractures of the medial epicondylar epiphysis, supracondylar fractures of the humerus, intercondylar fractures of the humerus, fractures of the olecranon, Volkmann's ischemic contracture, myositis ossificans, and olecranon bursitis (post-traumatic).

EXAMINATION AND DIFFERENTIAL DIAGNOSIS

In distinguishing between the various types of disturbances, the roentgenograms are of great help inasmuch as they are usually diagnostic of the suspected condition. However, careful clinical examination can lead the practitioner to a tentative diagnosis even before films are obtained.

Fracture of a single long bone within the forearm, such as an isolated fracture of the shaft of the radius or of the shaft of the ulna, is distinguished by a history of a direct injury (a blow sustained to the ulnar aspect of the forearm only as a result of the patient falling against the edge of a doorframe with the forearm lifted directly in front of the face) or of a falling object striking the forearm a glancing blow, hitting it on the radial side only, by swelling localized over the shaft of either the ulna or the radius, by no instability in the forearm (as found in a fracture of both bones of the forearm, for example), and by tenderness localized over the shaft of the involved bone. Therefore, a tentative diagnosis of an isolated fracture of the shaft of the radius or the ulna can be made before a roentgenogram is taken, and the distinction between it and a fracture of both bones of the forearm can be made.

*See also Chapter 1, Diseases or Affections in Childhood (page 101).

A tentative diagnosis of a fracture of both bones of the forearm is made on the basis of the following factors: history of an injury sustained as a result of the patient falling on his outstretched forearm, a forearm that is completely unstable through its midportion, tenderness over both the radius and ulna, and swelling that involves, in general, the entire circumference of the forearm.

Fracture of the head of the radius is suspected clinically by the patient's complaint of diffuse pain within the elbow as distinct from the forearm, especially painful pronation and supination (more painful than either flexion or extension of the elbow joint), swelling of the elbow joint itself, and marked and particular tenderness over the head of the radius on the posterolateral aspect of the elbow joint (quite distinct and different from the generalized tenderness which might be found around the elbow joint upon palpation).

Dislocation of the elbow is clinically rather easy to diagnose inasmuch as the deformity is likely to be quite typical: displacement of the forearm posteriorly to the humerus, palpation of the tip of the olecranon quite a distance from the epicondyle of the humerus, and palpation of a hollow space above and behind the olecranon where the posterior aspect of the distal humeral shaft is normally located.

An avulsion fracture of the epicondylar epiphysis is suspected when the patient is a teen-age boy who has sustained injury as a result of throwing a baseball or other object incorrectly and when the swelling is directly over the involved epiphysis on the sides of the joint (the swelling is usually medial inasmuch as it is the medial epicondylar epiphysis which is ordinarily avulsed).

A supracondylar fracture is suspected clinically and is differentiated from other fractures by its usual occurrence in children, a large fusiform type of swelling which starts above the elbow, surrounds the elbow, and extends for some distance below the joint, the typical fashion in which the patient holds the arm (in moderate flexion at the elbow, with the forearm maintained in a neutral position of supination and pronation), and by the way the patient grasps the hand and wrist of the involved arm firmly with the opposite hand and cringes in fear of pain when anyone approaches.

An intercondylar or "T" fracture is more difficult to distinguish clinically from some of the other fractures, inasmuch as there are no specific findings that set it apart. Each humeral condyle is split apart vertically as well as separated from the humerus by a transverse fracture. Provided the patient is an adult, intercondylar fracture is suspected if the elbow received relatively severe trauma, is very painful upon motion, and is in general swollen.

A fracture of the olecranon is ordinarily easy to distinguish clinically by a history of direct violence sustained at the tip of the olecranon, marked posterior swelling, and distinction of the separated fragment of the olecranon from the remainder of the ulna by palpation. It is possible to confuse the condition with a dislocated elbow because the swelling in a fracture of the olecranon may produce a deformity which resembles that in a dislocated elbow.

A previous Volkmann's ischemic contracture is ordinarily suspected when there is a previous history of either a supracondylar fracture of the humerus or a fracture of the midshaft of both bones of the forearm and when inspection

of the forearm, wrist, and hand reveals extensive disability and deformity: atrophic forearm, wrist held in marked flexion, fingers contracted in a claw position. Movement of the elbow may or may not be limited, but pronation and supination ordinarily are limited. Active grasp and release of the fingers are almost impossible.

Myositis ossificans may be difficult to diagnose in the absence of x-ray pictures. There is ordinarily a previous history of a dislocation of the elbow or fracture of the head of the radius, followed by a progressive loss of movement in the elbow joint so that both flexion and extension, as well as pronation and supination, may be markedly limited.

Post-traumatic olecranon bursitis is a simple condition to diagnose upon inspection and examination inasmuch as the bursa overlies the olecranon, is located subcutaneously, is swollen, tender, and reddened, and can be palpated as distinct from the underlying bone. At times, it may be necessary to distinguish between post-traumatic olecranon bursitis and fracture of the olecranon. The roentgenograms, of course, confirm the differential diagnosis.

TRAUMATIC INJURY TO THE FOREARM AND ELBOW

Complaint	Likely Diagnoses	Page
Pain and disability in forearm and elbow	(1) *Fracture of shaft of radius or ulna*	316
	(2) Fractures of midshafts of both bones of forearm	317
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Fracture of Shaft of Radius or Ulna

In a fracture of the shaft of the radius or ulna, the patient complains of pain and disability in the forearm and elbow The clinical findings are swelling overlying the shaft of either the radius or the ulna, tenderness to palpation directly over the fracture site, and lack of tenderness over the alternate bone. There is no generalized instability of the forearm. It is not common to encounter a fracture of the midportion of the shaft of the radius alone (the ulnar being intact) or of the midportion of the shaft of the ulna alone (the radius being intact). It is likely that this type of fracture results from a direct violence. For example, in falling a patient might raise the forearm to protect the face and strike the forearm directly upon a sharp corner, such as a doorframe. In such a circumstance, a single fracture of either the radial or ulnar shaft might be sustained. Mechanically, the situation is comparable to an isolated fracture of the tibia (the fibula being intact), that is, the intact bone may act as an internal strut or support for the fractured bone. Consequently, angulation, displacement, and overriding are not especially prone to occur. Hence, manipula-

tive reduction is usually not indicated. Treatment usually consists of simply applying a circular plaster cast from the midhumerus to the metacarpophalangeal joint, with the elbow at right angles and the forearm in midposition with regard to pronation and supination.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for eight to ten weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he should note that there will be none.

Fractures of the Midshafts of Both Bones of the Forearm

A fall upon the outstretched hand, wrist, and forearm, particularly in a child, is commonly followed by a complaint of pain and deformity or instability of the forearm. Fractures of both bones of the forearm in the region of the mid-

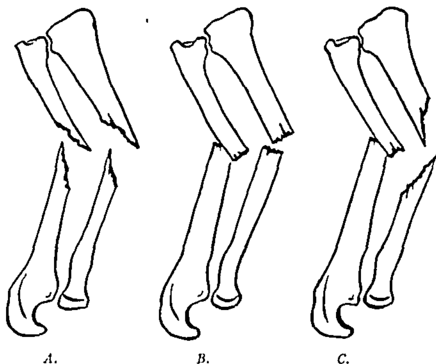


Fig. 149.—*A*, *B*, and *C*, Types of fractures of both bones of the forearm midshaft.

shaft are common and can be very serious. There are several types. In *Type I* the fracture surfaces of both the radius and the ulna may be oblique. (Fig. 149, *A*.) In *Type II* the fracture surfaces of both bones may be transverse. (Fig. 149, *B*.) In *Type III* the fracture surface of the radius may be oblique and that of the ulna may be transverse, or vice versa (that is, transverse on the radius and oblique on the ulna). (Fig. 149, *C*.)

In fractures of the midshafts of both bones of the forearm, neither bone can act as an internal splint for the other. Therefore, there is no stability, and the situation mechanically is analogous to a fracture of a single long bone, such as the femur or humerus. Consequently, displacement, angulation, and overriding are likely to occur. In choosing the method of treatment, certain factors must be kept in mind.

The pronator teres muscle inserts on the radial border of the radius around the midshaft. The supinator muscles, mainly the supinator brevis and the biceps brachii, exert their forces on the forearm proximal to the pronator teres. When the fracture line occurs just *distal* to the insertion of the pronator teres muscle, it is believed that the muscles of pronation are about balanced by the muscles of supination (both acting on the proximal fragments). Therefore, it is expected that the proximal fragments will take a position *midway* between pronation and supination. If this is true, then it is expedient to place the distal fragments in midposition (with regard to pronation and supination) in order to match the position of the proximal fragments (position the controllable fragments to match the uncontrollable fragments). When the fracture line occurs just *proximal* to the insertion of the pronator teres muscle, it is believed that the proximal fragments have been derived of pronator force and that the muscles of supination are unopposed; that is, the pronators act on the distal fragments and the supinators act on the proximal fragments. Therefore, the proximal fragments will tend to take a position of *supination*. Consequently, under such circumstances, it is common practice to place the distal fragment in supination in order to match the position of the proximal fragments. Due to these factors, then, fractures of the midshafts of both bones of the forearm are immobilized most commonly in either supination or midposition, depending upon whether the fractures are proximal or distal to the insertion of the pronator teres muscle. Another important reason for such a position of the forearm is that synostosis or cross-union of the radius and ulna might occur (with loss of pronation and supination) unless as large a space as possible is maintained between the two bones. Full supination and midposition tend to maintain an adequate space between the radius and the ulna, whereas pronation, of course, reduces such a space.

Another factor to consider is the expected stability at the fracture sites. Hence, one must determine whether the fracture lines are both transverse, both oblique, or one transverse and one oblique. If both fracture lines are transverse, it is quite possible to reduce the fracture by manipulation and to apply a cast. The cast should start from the midshaft of the humerus, pass downward over the elbow at 90 degrees of flexion, include all of the forearm in supination or midposition (see preceding paragraph), and end at the metacarpophalangeal joint. Stability is usually maintained. If one fracture site is oblique and one transverse, it is questionable whether sufficient stability can be obtained. However, manipulative reduction and the application of a cast can be tried. X-ray pictures should be taken at weekly intervals If angulation, overriding, or some other loss of position should start, then other procedures, including open reduction, are instituted. If both fracture sites are oblique, little if any hope of gaining stability remains. Therefore, open reduction with internal fixation is ordinarily performed.

The affected part is immobilized for approximately eight weeks. We emphasize, however, that the cast is not discarded until union is demonstrated by clinical and roentgenographic tests

In summary, a reasonable program in the treatment of a fracture of both bones of the forearm is as follows· Observe first whether both fractures are transverse; if so, manipulative reduction and the application of a cast are usually

adequate treatment. If both are oblique, the method of choice consists of open reduction and internal fixation. If one is oblique and one transverse, manipulative reduction and the application of a cast can be tried, provided that very close follow-up by roentgenograms is carried out during the ensuing weeks until all danger of malposition is passed. Next, observe whether the fracture is proximal or distal to the insertion of the pronator teres (about the middle of the radial shaft). If it is distal, a midposition between pronation and supination is maintained. If it is proximal to the pronator teres insertion, the forearm is maintained in a position of supination.

Some of the complications of a fracture of both bones of the forearm are malunion in the form of angulation, synostosis or cross-union of the radius with the ulna, nonunion, and union in a malposition with regard to rotation; that is, the alignment may be excellent in the anteroposterior and the lateral planes, but the distal fragments may be pronated to a certain degree while the proximal fragments may be supinated to a certain degree.

In the treatment of malunion resulting in angulation, an osteotomy of both bones is performed. The angulation is corrected, internal fixation is applied, and the condition is managed as a fresh fracture.

Cross-union produces a severe disability of the forearm, since pronation and supination are obliterated thereby. Osteotomy can be performed through the synostosis and treatment carried out as for a fresh fracture.

Nonunion is managed by bone grafting, as is nonunion elsewhere; that is, the sclerotic ends are resected and bone grafts applied to both the radius and the ulna. In this connection, it may be pointed out that resection of the sclerotic ends can bedone with less concern over loss of length in the forearm than in the leg; that is, from a functional standpoint, lengthof the forearm is not so important as length of the leg.

Malrotation is overcome by performing an osteotomy, rotating the fragments to a correct position, and by treating the condition as a fresh fracture.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for twelve to fourteen weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he should note that there may be a loss in pronation and supination and that nonunion is common.

Fracture of the Head and Neck of the Radius

Since injuries around the elbow can lead to severe disabilities, they can be serious. The need for a good range of motion at the elbow to feed and care for oneself is obvious. The elbow serves not only to flex and extend the forearm, but also to pronate and supinate it as well. Unfortunately, it has a tendency to become stiff readily. Therefore, when managing injuries around the elbow, it is well to obtain a position which will be the most serviceable in the event that very little joint motion ensues later. Flexion of the elbow to 90 degrees, together with a midposition with regard to pronation and supination of the forearm, is a position that is often used as the most serviceable in the event stiffness ensues. In general, almost all fractures and dislocations around the elbow joint are immobilized in a position of flexion.

A patient can sustain a fracture of the head and neck of the radius by falling on an outstretched hand in such a way that the stress is transmitted to the head of the radius instead of to the distal radius. It may be well to point out that the head of the radius is within the elbow joint and *does not* refer to the distal radius (a common error among medical students). A fracture of the head and neck of the radius is often incurred by dislocating the elbow posteriorly. Thus fracture of the head of the radius and dislocation of the elbow are not infrequently associated.

Clinically, a fracture of the head of the radius is suspected if the patient complains of pain and disability in the forearm and elbow, especially upon pronation or supination or if the tenderness is very well localized over the head of the radius. The radial head can be easily palpated and is on the dorsum of the forearm, relatively close to the ulna, and is felt almost subcutaneously.

As a matter of convenience, fractures of the head and neck of the radius can be categorized as follows:

In children:

a. Epiphyseal separation between the head and neck of the radius

In adults:

a. Fracture of the head of the radius without displacement
b. Fracture of the head and neck of the radius with displacement
   (1) Those involving more than one third of the articular surface
   (2) Those involving less than one third of the articular surface

In children, the fracture is usually a separation at the epiphyseal line between the head and neck of the radius. (Fig. 150.) In many instances manipulative reduction is successful. If conservative measures fail, an operative procedure is performed in which the head is replaced upon the neck. A posterolateral incision is made, and the supinator brevis muscle is retracted distally and the dorsal branch of the radial nerve protected. Then the annular ligament is severed Ordinarily, simple replacement of the head upon the neck, without internal fixation, is adequate to maintain position. However, the fragments usually are more stable if the elbow is kept flexed. Pronation and supination are tested to determine their effect on the stability. In some cases flexion of the elbow and pronation of the forearm produce stability and in others they result in instability. Observation at the time of operation permits the operator to choose the best position It is important to suture the annular ligament tightly to increase stability A posterior molded plaster splint is applied following closure of the wound and is kept on for four to six weeks before motion is started. Physical therapy should be directed especially at obtaining pronation and supination of the forearm.

One type of fracture of the head of the radius in adults is a fracture, either comminuted or not comminuted, without displacement. (Fig. 151.) At times it is difficult even to see the fracture lines on a roentgenogram. Treatment is directed primarily toward preventing joint stiffness. Therefore, the elbow is immobilized in a position of flexion and the forearm in a position of supination,

using either adhesive tape or a posterior molded plaster splint, for only five days. Physical therapy is then started and consists at first of passive motion and is gradually increased to active motion.

A second type encountered in the adult is a fracture with displacement of the fragments. In this type there are at least two possible situations. In the first, one fragment may be badly displaced, but the majority of the head may be intact; that is, the displaced fragment may be less than one third the size of the radial head. In the second, the fragments may constitute more than one third of the articular surface. (Fig. 152.) If the displacement of the fragments involves less than one third the size of the head, the following pro-



Fig 150 —Fracture through the epiphyseal plate between the neck and head of the radius in a child, with marked displacement of the head (before treatment).

cedure is suggested A posterolateral incision is made and the supinator brevis muscle is retracted distally and toward the volar aspect of the forearm. Within the two planes of the supinator brevis, the dorsal branch of the radial nerve winds around the neck of the radius to the dorsum of the forearm. Since this nerve supplies the extensor muscles of the wrist and hand, it must be guarded carefully After retraction of the supinator brevis muscle, the annular ligament is incised, and the radial head and the elbow joint are exposed. The displaced fragment or fragments are removed, the joint is inspected for all loose chips, and the head of the radius is observed in all positions of flexion, extension, pronation, and supination. In other words, partial resection of the radial head or removal of the displaced fragment is performed. If more than one third of the

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fully, and the wound is closed. Such a procedure is essentially an arthroplasty. Immobilization is carried out with the elbow in flexion and the forearm in supination for about ten days, after which careful physical therapy is started.

In summary, the following should be kept in mind. In children the epiphyseal line is likely to be the site of the fracture so that the whole head is displaced upon the neck. Operative replacement without internal fixation is often necessary. In adults treatment of a fracture without displacement consists of immobilization, with the elbow in flexion, for a few days, followed by physical therapy. Treatment in a fracture with displacement consists of operative removal of the loose fragments, leaving the main portion of the head intact, or resection of the head, replacing it with a Vitallium mold. The procedure used (partial or complete resection) depends on whether more or less than one third of the head is involved in the displacement.

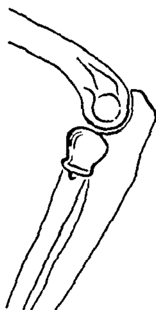


Fig 153.—Vitallium mold replacing a resected head of the radius.

At first thought, the treatment may seem radical. However, it is known that a fracture of the radial head leads frequently to an extensive and disabling arthritis of the entire elbow joint if much incongruity of joint surface remains after healing of the fracture. Therefore, the case should be weighed carefully at the onset and the more radical methods of treatment employed initially rather than after the joint has been ruined entirely by arthritic changes years later.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for six to eight weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he should note that pronation, supination, and extension of the elbow may be impaired and that post-traumatic arthritic is *common*

articular surface is involved *and* there is appreciable displacement, operative intervention is again indicated. The elbow joint is opened as just described. The head of the radius and a small portion of the neck are removed, and all loose fragments are cleared from the joint. The wound is then closed. Some prefer to insert a Vitallium mold, in the shape of a head and neck of the radius, to replace the removed bone. (Fig. 153.) The annular ligament is sutured care-

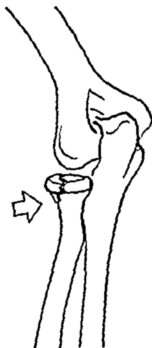


Fig 151.—Fracture of the head of the radius without appreciable displacement.

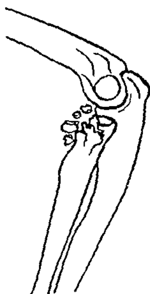


Fig. 152.—Comminuted and displaced fracture of the head of the radius involving more than one third of the articular surface.

out. Because of the possibility of Volkmann's ischemic contracture, a patient with a dislocated elbow may be admitted to the hospital for twenty-four hours for observation of the radial pulse and the circulation in the nail beds. If a flexion contracture should result to a disabling degree, anterior capsulotomy is performed.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for four to six weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he should note that a flexion contracture and anterior calcification may result.

Avulsion Fracture of the Medial Epicondylar Epiphysis of the Humerus

Frequently the medial epicondylar epiphysis of the humerus is completely avulsed when a teen-age boy throws a baseball incorrectly. The muscles taking

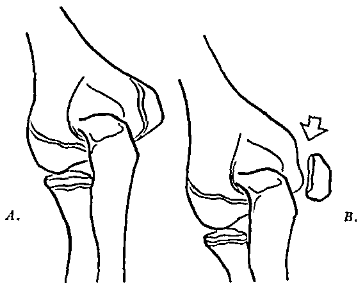


Fig. 155.—*A*, Normal elbow with medial epicondylar epiphysis in place. *B*, Avulsion type fracture of the medial epicondylar epiphysis displaced downward and outward by the pull of the flexor muscles of the forearm.

origin in this region are the flexors of the wrist. Consequently, the epiphysis is likely to be widely displaced downward by muscle pull. (Fig. 155, *A* and *B*.) It is to be remembered that the ulnar nerve passes just posterior to this site. Therefore, its function should be tested. If the displacement is marked, it is ordinarily impossible to obtain anatomic replacement either by flexion of the elbow or by manipulation. Since the fracture is at an epiphysis, good reposition of the fragment is necessary. Hence, operative intervention is frequent. An incision is made over the medial aspect of the elbow joint, the ulnar nerve is isolated and protected, and the epiphysis is replaced and held by silk sutures. Immobilization, with the elbow in flexion, is carried out for four weeks.

Two possible complications of this fracture are worthy of mention. The carrying angle at the elbow may be disturbed if anatomic reposition is not secured and a disturbing irritative ulnar neuritis may result because of the

Dislocation of the Elbow

The normal elbow joint has three bony prominences which aid in the diagnosis of fractures and dislocations around the elbow: the two epicondyles of the humerus and the tip of the olecranon. It will be noted that when the elbow is extended, these three prominences are on a line. When the elbow is at 90 degrees of flexion, the three prominences form an equilateral triangle. When the elbow is posteriorly dislocated, this normal relationship is markedly disturbed.

The common dislocation at the elbow is posterior. The radius and the ulna are carried inferior and posterior to the distal humerus. (Fig. 154.) The patient usually complains of pain and disability in the elbow and forearm.

Reduction is accomplished by exerting traction on the forearm in the line of the humerus (which is stabilized by an assistant) so that the coronoid process of the ulna clears the condyles of the humerus. Then the forearm is flexed slowly.

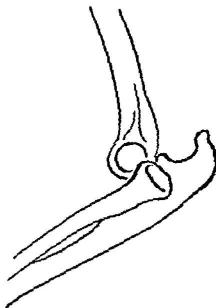


Fig. 154.—Posterior dislocation of the elbow.

The reduction can be clinically tested by noting whether there has been reestablishment of the normal equilateral triangle formed by the two epicondyles and the olecranon. The forearm is maintained in flexion and supination for two weeks, after which physical therapy is started.

Complications in this injury include concomitant fracture of the coronoid process of the ulna and/or of the head of the radius, vascular impairment leading to Volkmann's ischemic contracture, stiffening of the elbow joint so that extension is limited, and myositis ossificans or calcification of the anterior capsule of the elbow joint. If the injury (posterior dislocation of the elbow) is complicated by a fracture of the head of the radius, reduction of the dislocation is performed, and then treatment as just described for a fracture of the head of the radius is followed, provided immobilization for about two weeks is also carried

the forearm with the other hand. An assistant stabilizes the humerus. Then traction is exerted in the line of the humerus, and the elbow is manipulated anteriorly into flexion. The reduction can be clinically tested by noting whether the normal triangle formed by the olecranon and epicondyles is in proper relationship to the shaft.

Since the flexion used in the reduction may impair an already endangered circulation, it is necessary to make a rough test to determine the limits of safety. Therefore, flexion of the elbow is carried out until the radial pulse is obliterated. Then the elbow is put in 20 degrees of *extension* from the position at which the radial pulse was just obliterated. The patient is admitted to a hospital for twenty-four hours for observation of the radial pulse and circulation in the nail beds. If impairment occurs and the circulation does not improve by allowing

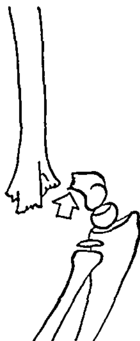


Fig. 156.—Supracondylar fracture of the humerus.

extension at the elbow, then immediate open reduction, severance of the deep fascia and a periarterial sympathectomy should be performed. Such treatment is recommended because of the extensive disability caused by Volkmann's ischemic contracture. All too commonly this complication follows a supracondylar fracture if the circulation is allowed to remain impaired.

In Volkmann's ischemic contracture the blood supply is somehow compromised. Some believe that spasm of the artery is responsible for the poor circulation. Others believe that the edema in the tight fascial compartments surrounding the elbow compresses the veins. At any rate, the muscles being deprived of their blood supply are replaced in the course of time by fibrous tissue, and clawing of the hand and contractures of the wrist and elbow are likely to ensue. The disability is so grave that every effort must be made to avoid the complication,

deformity of this bony prominence. Under such a circumstance, the ulnar nerve is stretched beyond its capacity by attempting to pass around the bony prominence. It may become involved in exuberant callus or scar tissue. The resultant neuritis manifests itself by pain, numbness, tingling, paresthesia along the distribution of the nerve, or even by a palsy of the motor components of the nerve. In treatment of such an irritative neuritis, it is possible to transfer the ulnar nerve anterior to the epicondyle. This procedure shortens the distance the nerve must travel and therefore diminishes the tension upon the nerve.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for six to eight weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he should note that there might be a loss of extension of the elbow.

Supracondylar Fracture of the Humerus

A supracondylar fracture of the humerus, which occurs most commonly in children, is a result of a fall on a pronated and partially flexed forearm. Both condyles of the humerus are carried posteriorly, while the elbow joint per se remains intact. The fracture line runs transversely just above the humeral condyles The patient complains of pain and disability in the forearm and elbow.

It is well to consider the lateral view of a roentgenogram of the normal elbow. It will be noted that the capitellum epiphysis is directed anterior to the line of the shaft by an angle of about 40 degrees. In some supracondylar fractures there is no real displacement of the distal fragment posteriorly. Instead, the capitellum epiphysis is aligned directly with the shaft instead of being inclined anteriorly by about 40 degrees or, in any event, the normal angle is considerably decreased. It is important to attempt to regain this normal forward angulation at the time of reduction, and the angle on the postreduction film is of aid in judging the adequacy of the reduction. In other supracondylar fractures, the distal fragment (including the entire elbow joint) is completely displaced posteriorly. (Fig. 156.) Many times the roentgenograms of elbows of children are confusing because of the number and position of the various epiphyses. Therefore, it is wise to obtain roentgenograms of both the injured and the normal elbow.

Clinically, there is characteristic fusiform swelling around the elbow joint. Typically, the patient (usually a child) grasps the wrist of the affected arm with his normal hand, attempting to maintain the forearm in midposition and the affected elbow in slight flexion. At times a deformity of the extremity just above the elbow joint is very apparent, and at first sight one might get the impression that the elbow is dislocated posteriorly. The triangle formed by the two epicondyles and the olecranon can sometimes be felt to be displaced in relation to the posterior aspect of the humerus.

Certainly this fracture represents an orthopedic emergency, since the swelling around the elbow joint increases hourly and the circulation is seriously endangered. Therefore, reduction should be performed as soon as possible. The operator grasps the posterior aspect of the elbow joint with one hand and

The displacement is usually significant, since this is an intra-articular fracture. The presenting complaints are pain and disability in the forearm and elbow. It is well to recall the general principles that intra-articular fractures require good reduction because of the possibilities of a later incongruity of joint surfaces, the blocking of joint motion, and the development of a painful and disabling arthritis. Therefore, open reduction is frequently performed.

In one method of treatment the condyles are joined by a transverse screw inserted through both of them and then are fixated to the humeral shaft by a plate.

Unfortunately it is common that, despite good open reduction, the elbow joint too often becomes very stiff following an intercondylar ("T") fracture of the humerus. Therefore, instead of open reduction, resection of the condyles is sometimes performed. In this operation, both of the humeral condyles, together with the flaring metaphyseal portion of the supracondylar region, are completely removed. The distal end of the humeral shaft is then smoothed off and placed in apposition with the articular surface of the ulna. In other words, a type of arthroplasty is performed. Vitallium replicas of the distal humerus have been made to replace the humeral condyles following resection. While motion is more likely to be obtained if resection is performed, it is true that there is a risk of resultant instability and pain. Therefore, it is necessary to weigh the possibility of marked elbow stiffness against the possibility of an unstable elbow when considering whether to perform an open reduction or a resection of the condyles. If motion is more important to the patient than power, resection is the better procedure; if power is the most important consideration, open reduction is better. At times, it is possible to treat intercondylar fracture of the elbow by skeletal traction. However, regardless of the method of treatment, these fractures should be considered serious injuries with a relatively poor prognosis.

If resection of the condyles is performed, movement of the elbow is started as soon as the wound is healed (about ten days postoperatively). If open reduction is performed, the injured part is immobilized in a shoulder spica for six to eight weeks.

In filling out an insurance form the practitioner should estimate that the patient will be totally disabled for twelve to fourteen weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he should note that stiffness is marked and common.

Fracture of the Olecranon

Fractures of the olecranon are often sustained by direct violence to the tip of the elbow. It is also probable that some are due to indirect violence, the fragment being avulsed by a violent contraction of the triceps muscle. Clinically, there is likely to be a large hematoma over the point of the elbow posteriorly, and the swelling may be so large as to give the impression of a posterior dislocation of the elbow. The presenting complaints are pain and disability in the forearm and elbow.

especially if it appears that an ischemic contracture impends. One of the most important warning signs of impending Volkmann's ischemic contracture is a complaint of pain. The patient complains of pain in the hand and forearm which is out of all proportion to the complaint ordinarily encountered in supracondylar fracture of the humerus after reduction and due to fracture alone. Therefore, if a patient complains of pain in the hand following reduction, the physician should especially observe the circulation in the nail beds, the adequacy of the radial pulse, and the general warmth or coolness of the hand. Two to three days after reduction, a special form of physical therapy called relaxed motion is started. Such motion depends on gravity and is to be distinguished from passive motion. It is even much more gentle than passive motion. Relaxed motion is carried out as follows. The cast or other means of immobilization is removed. The elbow is gently elevated in a forward plane, and the forearm is allowed to fall into flexion by the pull of gravity. The elbow is then lowered, and the forearm is allowed to fall into extension, again by gravity. Thus, early movement is used to combat stiffness of the elbow joint. Following each treatment with relaxed motion, the arm is of course again immobilized. If the fracture is badly displaced, it is perhaps wise to allow ten days to two weeks of immobilization before starting relaxed motion.

Another complication of supracondylar fracture of the humerus involves the carrying angle at the elbow. Normally, the supinated forearm is directed laterally from the line of the humerus by a small angle when the elbow is completely extended. Such an angle is called the carrying angle. In a supracondylar fracture the carrying angle is increased to such a degree that deformity results; that is, the forearm passes laterally from the line of the humerus far more than it should. As a secondary complication of this, the medial epicondyle may irritate the ulnar nerve and lead to ulnar neuritis. Should the carrying angle be increased to such an extent as to produce a marked disability, a supracondylar osteotomy is performed, and the angle is corrected. After surgical exposure of the supracondylar area of the humerus, a wedge of bone is removed from the medial aspect of the humerus. The forearm is then swung medially and the wedge-shaped space in the bone is closed. Naturally, it is necessary to remove a wedge large enough to allow the forearm to be properly aligned; that is, the abnormal increase in the carrying angle is decreased to normal. If ulnar neuritis results, it is possible to transfer the nerve from behind the epicondyle to a position in front of it.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for six to eight weeks and partially disabled for an additional two to four weeks. Under "Anticipated Loss" he should note that there may be loss of extension and the possibility of Volkmann's ischemic contracture.

Intercondylar Fracture or "T" Fracture of the Humerus

In adults, a fracture in the form of a "T" sometimes occurs in the distal humerus. The fracture line runs transversely just above the condyles, and a vertical line passes downward between the two condyles, splitting them apart.

instead of wire. It is inserted longitudinally through the olecranon, across the fracture site, and into the ulna after open reduction has been accomplished.

One of the main complications of a fracture of the olecranon is fibrous union (or nonunion), which can occur regardless of the type of treatment and which results in a weak, painful elbow.

In filling out an insurance form, the practitioner should estimate that the patient will be totally disabled for eight to ten weeks and partially disabled for an additional four to six weeks. Under "Anticipated Loss" he should note that nonunion is common.

Volkmann's Ischemic Contracture

The practitioner must be acutely aware of an unusual, but extremely disabling, complication which occurs in fractures—Volkmann's ischemic contracture. It is most likely to be a complication in supracondylar fractures of the humerus, fractures of both bones of the midshaft of the forearm, and possibly dislocations of the elbow. Numerous theories on the etiology of this condition have been offered. Some believe that the hemorrhage attendant upon a fracture

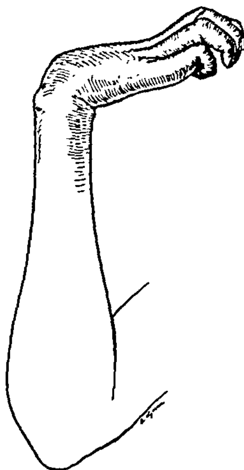


Fig. 158.—Well-established Volkmann's ischemic contracture with clawhand and flexion of the wrist and fingers. Note atrophy of forearm. (*From Larson, C. B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, the C. V. Mosby Co.*)

A fracture of the olecranon is quite similar in type, mechanism, healing ability, treatment, etc., to a fracture of the patella. In both fractures, muscle pull is often responsible for the position of the fragments (the triceps in the one case and the quadriceps in the other). In both instances the fracture enters a joint, both often require open reduction and wiring, and both have a tendency toward fibrous instead of bony union. Fractures of the olecranon are likely to be compound because of the superficial location of the bone.

There are two main types of fracture of the olecranon—those with little or no separation of the fragments, and those with wide separation of the fragments.

In the treatment of a fracture with little or no separation of fragments, immobilization, with the elbow in moderate *extension*, is adequate. However,

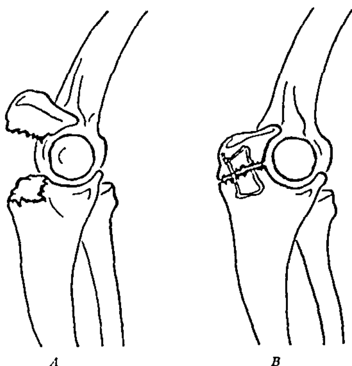


Fig. 157 —*A*, Fracture of the olecranon with displacement of fragments due to pull of the triceps muscle *B*, Fracture reduced and held by wire.

there is a tendency for the union to be fibrous instead of bony. Fibrous union can result in a weak, painful elbow. Close apposition of the fragments provides a chance of avoiding fibrous union. Therefore, if much separation (Fig. 157) or comminution is present, open reduction is indicated. An incision is made in the midline overlying the olecranon Wire is passed through a transverse drill hole in the ulna. Then the wire is either looped superior to the proximal fragment and deep in the triceps tendon or passed through a drill hole in the proximal fragment itself. In either event, the fracture is reduced, and the wire is made tight. Thus, the wire roughly forms a square. Immobilization is carried out for four weeks before physical therapy is begun. Sometimes a screw is used

If there are signs of impending Volkmann's ischemic contracture, consultation should be held, and certain procedures should be instituted without delay. The constricting bandages and cast should be removed from the arm. The elbow should be placed in more extension by several degrees, and the circulation should be observed closely for the next fifteen to twenty minutes. If immediate return of adequate circulation is not apparent within that time, then operation upon the affected area, usually the elbow, should be undertaken. The operation consists of severance of the deep fascial planes (leaving them unsutured), evacuation of any hematoma, open reduction of the fracture, visualization of the arterial supply, and possibly periarterial sympathectomy. If, following such procedures, the physician is still not satisfied with the adequacy of the circulation, repeated cervical sympathetic blocks can be performed.

If Volkmann's ischemic contracture has already developed when treatment is sought, numerous operative procedures to improve function somewhat are available. Both bones of the forearm may be shortened to give the contracted muscle and tendon systems a relatively greater length in order to allow better mechanical function. Other procedures include fusion of the wrist in a position of optimum function, tendon lengthening, etc. In the most severe cases, amputation and replacement by prosthesis can be done.

It certainly should be clear that prevention of the complication in the first place or rapid and adequate treatment of an impending Volkmann's ischemic contracture is far better than reconstructive procedures after the complication has already developed and is of some months standing.



Fig. 159 —Myositis ossificans of the elbow.

Myositis Ossificans

A dislocation of the elbow is sometimes followed by the relatively disabling complication of myositis ossificans or calcification of the anterior capsule of the elbow joint. The patient is likely to complain of pain and stiffness in the elbow which persists for several weeks after the original dislocation of the elbow or fracture of the head of the radius. Examination reveals that there is a marked

and the edema compress the vascular and nerve bundles at the elbow beneath the tight fascial compartments, leading to an ischemia of the forearm. Others believe that, due to irritation of the rough fractured ends, the artery undergoes a reflex spasm to such a degree that circulation to the forearm is cut off almost entirely. Still others maintain that the arterial supply is normal and that the venous return is blocked, leading to circulatory stagnation within the forearm. Whatever may be the fundamental cause of Volkmann's ischemic contracture, it is apparent that there is a partial loss of the blood supply to the forearm, causing the muscles of the forearm to undergo necrosis, degeneration, and replacement by fibrous scar tissue. In addition, the function of both the motor and sensory nerves supplying the forearm is impaired. The result of this vascular disaster is that the forearm, wrist, hand, and fingers become practically useless. *The wrist is held rigidly in flexion, the fingers are held in clawhand,* and there is very little, if any, active voluntary control of the movement of the fingers, hand, wrist, and forearm. (Fig. 158.) Needless to say, every effort should be made to avoid the occurrence of this complication in the first place. An awareness that the complication can develop in a supracondylar fracture, a dislocation of the elbow, and a fracture of both bones of the forearm will aid in its prevention.

There are certain danger signals which must be heeded in the aftertreatment of fractures, especially those three injuries of the elbow and forearm just mentioned. The danger signals are an increase in the swelling of the forearm and wrist, a fading or obliteration of the radial pulse, a duskiness or cyanosis in the nail beds, sluggish circulation in the nail beds upon pressure and release of the nail, and a persistent and compelling pain in either the forearm or hand out of proportion to that which might be expected from the fracture per se. In connection with this latter point, it should be clearly understood that, following reduction of a dislocation of the elbow, a supracondylar fracture of the elbow, or a fracture of both bones of the forearm, it is common to expect a certain amount of low-grade discomfort. It is distinctly unusual for a patient to continue to complain of pain for any length of time. Therefore, the practitioner is well advised to question the attendants, the nurses, and the patient with regard to the degree of pain after treatment, particularly during the first twenty-four to forty-eight hours. A patient with an injury such as a supracondylar fracture should be hospitalized for at least twenty-four hours following reduction specificially for the observation of the adequacy of the radial pulse and of the circulation in the nail beds It is also well to keep in mind that in the treatment of these injuries it is distinctly dangerous to apply tight or constricting bandages or too constricting a plaster cast, inasmuch as either of these may aggravate or precipitate Volkmann's ischemic contracture. Hence, in managing a supracondylar fracture of the humerus, a dislocation of the elbow, or a fracture of both bones of the forearm, the practitioner is strongly urged to hospitalize the patient for observation, *not* to place constricting bandages or a tight cast on the arm, and to inquire about the pain the patient experiences.

bursitis of the elbow (due to repeated small traumas) which subsided in the course of time, leaving a swollen sac in the region of the olecranon bursa. Such a sac is not particularly painful nor tender to palpation.

Treatment for these various types of olecranon bursitis can be varied. It is the same in acute irritative olecranon bursitis and acute hemorrhagic olecranon bursitis. The bursa is aspirated, and Hydrocortone is instilled. A compression bandage is placed on the olecranon bursa, and a thick padding is placed around the elbow, which is put in a sling to protect and to immobize it. Ice bags are also used. An alternative method consists of incision and drainage of the bursa, followed by the application of a compression bandage, ice bags, and supportive bandages and the restriction of activity. Another alternative method consists of the immediate surgical excision of the entire bursa. Treatment for acute suppurative bursitis consists of surgical incision and drainage of the bursa and the administration of adequate amounts of the antibiotic to which the organism is most sensitive as determined by sensitivity studies on the cultured material from the bursa. Treatment for chronic irritative olecranon bursitis consists of excision of the bursal sac if the patient complains of much annoying discomfort, pain, or tenderness. If the swelling does not annoy the patient, he is simply reassured that the condition is not harmful, and no special treatment is carried out.

NONTRAUMATIC DISORDERS OF THE FOREARM AND ELBOW

Complaint	Likely Diagnoses	Page
Spontaneous (nontraumatic) pain around elbow	(1) Tennis elbow (lateral epicondylitis)	335
	(2) Osteochondritis dissecans	336
	(3) Rheumatoid arthritis	337
	(4) Hypertrophic arthritis	337
	(5) Acute suppurative arthritis	337
	(6) Acute hematogenous osteomyelitis	338
	(7) Tuberculous arthritis	338

Tennis Elbow (Lateral Epicondylitis)

The practitioner should be especially conscious of a very common complaint in the elbow. A routine history is that of a gradual development of pain localized rather vaguely in the outer aspect of the elbow joint, frequently radiating down the dorsum of the forearm and fading away as it approaches the wrist. The patient may state that pain is experienced when grasping an object with considerable force and is likely to complain also of experiencing pain upon twisting movements of the forearm, such as might be felt when using a screw driver. Another complaint is that lifting an object, such as a tea kettle of water from a stove, may be impossible because of pain. It is apparent that rotation of the forearm or extension of the wrist while using force in the grasp are the motions likely to cause pain. Clinical examination reveals a sharp point of tenderness, which is fairly small, either directly over the lateral epicondyle of the humerus or over the head of the radius. If this area of tenderness is present, the patient is requested to extend the wrist against resistance offered by the examiner. When the patient performs this motion, he complains of pain in the epicondyle

loss of motion at the elbow joint to such an extent that flexion and extension may be reduced to 40 to 60 degrees around the midportion of the normal arc of the elbow. There may be a loss of 45 degrees of extension and 20 to 40 degrees of flexion. In addition, whereas pronation might be normal, supination may be *only 45 degrees from midposition, rather than a full 90 degrees, as is normal.* X-ray pictures reveal calcification anterior to the elbow joint which may be situated in the brachialis anterior muscle or in the anterior capsule of the elbow joint. (Fig. 159.)

Treatment of this complication consists mainly of operative resection of the calcified mass. It is probably preferable to wait until the complete extent and maturity of the calcification or ossification can be determined. If excision of the calcific mass is made before the process reaches maturity, it can be anticipated that the calcium will re-form. If, however, the physician waits until there is no further tendency for calcium or new bone to form, excision of the mass can be successful in obtaining some increase in the function and preventing a recurrence of the calcification or ossification.

Olecranon Bursitis (Post-Traumatic)

Very commonly patients complain of a painful swelling around the elbow. Examination reveals a swelling, which may be reddened and tender, situated subcutaneously and overlying the olecranon process of the ulna. The diagnosis is easily made by clinical examination; the x-ray pictures ordinarily are negative, although they may show a subcutaneous swelling. Occasionally, some small calcific specks may be seen on the x-ray pictures in the region of the swelling and pain.

Beneath the skin and overlying the olecranon process of the ulna at the elbow is a bursa or sac. This sac can be irritated by repeated striking of the elbow, such as might be done by an office worker with a habit of leaning his elbow upon a desk. When the bursa is subjected to small, repeated traumas, it becomes filled with fluid and irritated, the surrounding tissue becomes reddened, and the patient complains of pain and tenderness of the swelling. Such a condition is called acute olecranon bursitis. At times the history may be of a single sharp blow at the point of the elbow, followed by an immediate swelling in the area. In the case of the repeated small traumas, the fluid within the bursal sac is quite comparable grossly to the synovial fluid of a joint. The fluid within the bursal sac that occurs as a result of a single relatively severe trauma to the point of the elbow is hemorrhagic These two types are acute olecranon bursitis, one is acute irritative and one acute hemorrhagic, but neither is suppurative.

It is also possible, by repeatedly striking the elbow, particularly in an unsanitary situation, for the bursal sac not only to become inflamed and irritated, but to be invaded by a pyogenic organism as well. This condition is called suppurative bursitis. Frequently suppurative bursitis occurs in men engaged in coal mining as a result of frequently striking their elbows against the dirty sidewalls of the tunnels in which they work. Therefore, suppurative olecranon bursitis is also called "miner's elbow." A fourth type is chronic irritative bursitis. In this condition the patient originally may have suffered an acute, irritative

activity and the pain, sometimes the patient notices difficulty only after some strenuous activity, such as tennis. The roentgenograms indicate the diagnosis of osteochondritis dissecans, with probably a loose body in the elbow joint. Clinical examination is not helpful. It may reveal simply an effusion in the elbow joint as manifested by swelling beneath the triceps tendon posterior to the elbow or obvious limitation of motion in the elbow joint apparently due to muscle spasm. These are nonspecific findings. Diagnosis depends upon the roentgenograms.

Treatment consists of surgical excision of the loose body and curettage of the bed from which the loose body originated.

Rheumatoid Arthritis

If a patient complains of spontaneous pain and swelling in the elbow, inquiry should be made with regard to joint pain in the interphalangeal joints of the fingers or the metacarpophalangeal joints of the hands. Often the patient complains of one particular joint only, since that joint is the one which bothers him the most from the standpoint of frequency or severity of the pain. Unless the practitioner inquires about joint pain elsewhere, a condition of generalized rheumatoid arthritis may very well be overlooked. As a rule the roentgenograms are not helpful in establishing a diagnosis of rheumatoid arthritis, and the history of the disturbance is the main method of diagnosis. It should not be forgotten that pain in the elbow due to rheumatoid arthritis is only one episode in a general systemic disturbance. The condition should be treated from a general systemic standpoint, as discussed elsewhere. See Chapter 12, Arthritis (page 366).

Hypertrophic Arthritis

Hypertrophic arthritis of the elbow occurs relatively infrequently. The patient complains of pain in the elbow which he describes as an annoying ache, with a tendency to get worse at times, to improve at other times, and to be particularly susceptible to changes in the weather. The patient is likely to be obese or robust and in an older age group. Examination is likely to reveal the deformities of the distal interphalangeal joints to be associated with hypertrophic arthritis. Roentgenograms are helpful in establishing that the joint surfaces are rough and irregular, the typical hypertrophic changes. Conservative treatment consists of diathermy, of rest for the affected part in a sling, or of intra-articular instillation of Hydrocortone See Chapter 12, Arthritis (page 366).

Acute Suppurative Arthritis

Acute hematogenous suppurative arthritis occurs more often in children than in adults and does not often involve the elbow. However, the practitioner should keep the condition constantly in mind when dealing with a child who complains of pain and swelling in the elbow, has an elevated temperature, and appears to be systemically ill For a complete discussion of the condition, see Chapter 12, Arthritis (page 366).

or over the common tendon of origin of the extensor muscles of the forearm. The reverse motion of flexing the wrist against resistance offered by the examiner does not cause pain. The patient is then requested to hold the elbow at his side and to supinate the forearm against resistance offered by the examiner while the examiner grasps the patient's hand. This motion causes pain in the outer or lateral aspect of the elbow joint in the region of the lateral epicondyle. Pronation of the forearm in this position against the resistance offered by the examiner who holds the patient's hand does not cause pain. It should be apparent from clinical examination that active resistive motion which puts a stress upon the common tendon or origin of the extensor muscles of the forearm in the region of the epicondyle of the humerus and in the region of the head of the radius is painful and that the reverse motion is not. The roentgenograms are negative.

The exact pathologic changes which take place are not clearly understood. It is thought that lateral epicondylitis is actually an inflammatory condition which involves the common tendon of origin of the extensor muscles of the forearm and/or the lateral epicondyle of the humerus. Some also believe that there is an irritative bursitis between the common tendon of origin of the extensor muscles and the head of the radius.

In conservative treatment Novocain and Hydrocortone are injected into the epicondyle or the common tendon of origin of the extensor muscles. Following the injection, the tender area and the pain caused by active resistive extension of the wrist and active resistive supination of the forearm disappear immediately. Within a few hours there is ordinarily a flare-up of pain quite comparable to that which occurs following an injection for bursitis in the shoulder. It is well to advise the patient that this flare-up is likely to occur. The elbow is placed at rest in a sling, and ice bags are applied continuously. Narcotic medication may be necessary to control the severe pain. However, after this initial flare-up of pain, it is common for all signs and symptoms of the original condition to subside within seven to ten days following injection.

If the patient does not wish to have the injections of Novocain and Hydrocortone, then immobilization of the elbow by a posterior molded plaster splint can be carried out for three to four weeks in the hope that the process will subside. Diathermy is at times successful in causing the process to subside. In some cases, particularly those of long standing, injection may fail, as well as may immobilization or diathermy Under such circumstances, operation is undertaken. The common tendon of origin is surgically cleared of any adhesions, and the area beneath it and overlying the annular ligament surrounding the head of the radius is also cleared of any scar tissue or possible bursal tissue. Usually this operation gives relief.

Osteochondritis Dissecans

Occasionally, although not too commonly, an otherwise healthy person complains of recurrent episodes of pain and swelling in the elbow. There is no other arthralgia anywhere in the body and seemingly no particular association between these recurrent episodes of pain and swelling in the elbow and any special trauma, overuse, etc. Although there is usually no association between

activity and the pain, sometimes the patient notices difficulty only after some strenuous activity, such as tennis. The roentgenograms indicate the diagnosis of osteochondritis dissecans, with probably a loose body in the elbow joint. Clinical examination is not helpful. It may reveal simply an effusion in the elbow joint as manifested by swelling beneath the triceps tendon posterior to the elbow or obvious limitation of motion in the elbow joint apparently due to muscle spasm. These are nonspecific findings. Diagnosis depends upon the roentgenograms.

Treatment consists of surgical excision of the loose body and curettage of the bed from which the loose body originated.

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Hypertrophic arthritis of the elbow occurs relatively infrequently. The patient complains of pain in the elbow which he describes as an annoying ache, with a tendency to get worse at times, to improve at other times, and to be particularly susceptible to changes in the weather. The patient is likely to be obese or robust and in an older age group. Examination is likely to reveal the deformities of the distal interphalangeal joints to be associated with hypertrophic arthritis. Roentgenograms are helpful in establishing that the joint surfaces are rough and irregular, the typical hypertrophic changes. Conservative treatment consists of diathermy, of rest for the affected part in a sling, or of intra-articular instillation of Hydrocortone. See Chapter 12, Arthritis (page 366).

Acute Suppurative Arthritis

Acute hematogenous suppurative arthritis occurs more often in children than in adults and does not often involve the elbow. However, the practitioner should keep the condition constantly in mind when dealing with a child who complains of pain and swelling in the elbow, has an elevated temperature, and appears to be systemically ill. For a complete discussion of the condition, see Chapter 12, Arthritis (page 366).

Acute Hematogenous Osteomyelitis

If a child complains of pain and swelling around the elbow, is systemically ill, and has an elevated temperature, the practitioner must consider acute hematogenous osteomyelitis as well as acute hematogenous suppurative arthritis as the most likely diagnoses. For a complete discussion of the conditions, see Chapter 12, Arthritis (page 366).

Tuberculous Arthritis

Today it is extremely uncommon to encounter tuberculous arthritis as the cause of pain and swelling in the elbow. However, it is just sufficiently common that it cannot be overlooked or forgotten when a patient presents such a complaint. It should be remembered that tuberculous arthritis anywhere in the body must by its nature be secondary to a primary tuberculous infection elsewhere in the body, particularly in the lungs, the gastrointestinal tract, or the genitourinary tract. Diagnosis depends upon the observation of a chronically ill patient with tuberculosis elsewhere in the body, as established by x-ray pictures of the chest, by the guinea pig inoculation test (inoculations of the fluid aspirated from the joint in question), and by a positive tuberculin skin test. The roentgenograms will sooner or later show destruction of a type which can be diagnosed radiographically as tuberculosis.

In the general treatment, the patient is placed at bed rest and given a high-caloric, high-vitamin diet and specific antibiotics, such as streptomycin, in conjunction with para-aminosalicylic acid. Local treatment consists of placing the joint at rest in a cast, taking care to place the elbow and forearm in a position of optimum function. Should the infection in the elbow continue and progress in spite of these measures, arthrodesis should be performed, placing the elbow in in a position of optimum function.

Chapter Ten

*Disturbances of the Wrist and Hand in the Adult**

Disturbances of the wrist and hand are more likely to be associated with injury or due to injury and its consequences than to nontraumatic disorders. For this reason, the emphasis is on those conditions due to traumatic injury. As a corollary to this, it should be noted that the roentgenograms are of particular aid in making differential diagnoses. If the complaint is of pain and disability in the fingers, hand, or wrist following injury, the practitioner should think first in terms of fractures and dislocations of these structures, and the x-ray pictures are expected to indicate the exact diagnosis. However, the possibility of those conditions which might occur some time after injury, such as rupture of the extensor pollicis longus, post-traumatic osteitis of the carpal bones, post-traumatic paralysis of the median and ulnar nerves, and reflex sympathetic dystrophy, should also be kept in mind. If the complaint involves pain and disability mainly of the fingers and is not particularly associated with trauma, the practitioner should consider such conditions as tenosynovitis, de Quervain's disease, snapping finger, Dupuytren's contracture, ganglion, post-poliomyelitic opponens paralysis, rheumatoid arthritis, etc.

TRAUMATIC INJURIES TO THE WRIST AND HAND

Complaint	Likely Diagnoses	Page
Following Recent Injury		
Pain and disability of fingers, hand, or wrist	(1) Fractures and dislocations of:	
	(a) Phalanges	340
	(b) Metacarpals except that of thumb	343
	(c) Metacarpal of thumb	344
	(d) Carpus .	344
	(e) Distal radius and ulna (Colles' fracture)	346
	(f) Distal one third of radius and ulna .	351

(Continued on following page.)

*See Chapter 1, Diseases or Affections in Childhood, for additional information

Complaint	Likely Diagnoses	Page
Weakness in hand after injury Inability to oppose thumb to index finger Inability to flex fingers, especially 4th and 5th at metacarpophalangeal joints	(1) Post-traumatic median or ulnar nerve paralysis	351
Persistent, severe pain in hand or hand and shoulder following major or minor injury	(1) Reflex sympathetic dystrophy	352
Following Previous Injury		
Sudden inability to extend thumb following previous injury	(1) Delayed rupture of extensor pollicis longus	353
Pain and swelling of wrist following previous injury	(1) Post-traumatic osteitis (Kienbock's disease, Preiser's disease)	353

Fractures and Dislocations

Phalanges

Fractures of the phalanges are extremely common, and the result of treatment is often surprisingly poor. Because of the large number of persons engaged in industries which necessitate contact with moving machinery, the finger injuries are very common. Some reason for the disappointing results in the treatment of finger injuries is apparent if the anatomy of the finger is considered. The joints are small, and normal motion is even less than in many other joints. The function of the hand is impaired quite severely by a relatively small amount of limitation of motion of a finger. The tendons moving the fingers are closely applied to a long surface of bone and therefore are likely to be bound down by adhesions or new bone formation rather easily Therefore, stiffness of the joints develops rapidly We strongly warn against immobilizing fractures or dislocations of phalanges too long Many times, disabling stiffness results thereby. Two weeks is usually plenty of time in the ordinary fracture. The presenting complaints are pain and disability of the finger.

Compound Fracture.—This fracture of the phalanx is especially common and is treated according to the general principles followed in any compound fractures. Often the injury is so severe that the distal portion of the phalanx hangs by a small shred of tissue only, and hence amputation is not uncommon.

Comminuted Fracture.—As a result of a crushing injury, the distal phalanx may be comminuted, ordinarily without much displacement of fragments. In this type of fracture, application of a simple, padded, molded metal splint for two weeks is adequate treatment. Another method of treatment

consists of strapping the part with multiple small strips of adhesive tape and applying ice compresses. Not infrequently a painful subungual hematoma forms. In such a case, the nail is drilled to relieve the tension of the hematoma. The distal interphalangeal joint is ordinarily intact in fractures of this kind. The affected part should not be immobilized for longer than two weeks unless so advised by a competent consultant.

Transverse Fracture.—The proximal and middle phalanges of any given finger are prone to suffer a transverse fracture. Many times there is no angulation, overriding, or displacement; in such instances, application of a padded molded metal splint for two weeks is adequate. If angulation or overriding is present, reduction and splinting are necessary. However, the splint should not be left on for too long a time.

Oblique Fracture.—In an oblique fracture of the proximal and middle phalanges there is a natural tendency to angulate or override. The deformity tends to recur if splinting as in a transverse fracture is tried. Therefore, traction is the recommended method of treatment. The traction is applied by attaching strips of adhesive tape to the skin of the finger. Then an elastic band (to exert traction) is passed from the adhesive tape to a metal hoop (known as a banjo splint). The banjo splint is attached to a cast at the wrist, passing in an arc well distal to the finger tips. It is possible to apply *skeletal* traction to the phalanges in place of the adhesive-skin type. The finger remains in traction for two weeks.

Intra-Articular Fracture.—This fracture can occur at either the metacarpophalangeal joints or the proximal or distal interphalangeal joints. At times, an intra-articular fracture can be placed in satisfactory position by molding the affected area, using external pressure. Then the affected part is immobilized. However, if a satisfactory position cannot be obtained in this manner, traction is used as an alternative method. It is difficult to obtain a good result in a moderately severe intra-articular fracture of the phalanx. Splinting should not continue for more than two weeks.

Fracture of the Epiphyseal Plate.—In children, a fracture of the phalanx sometimes involves the epiphyseal plate in such a manner that the shaft of the phalanx is displaced away from the epiphysis. In this fracture there must be an excellent reposition of the fragments, and such is usually accomplished by manipulation. If manipulation fails to obtain alignment, traction or even open reduction should be used. Two weeks of immobilization of the part is sufficient.

Avulsion Fracture.—Avulsion fractures of the phalanges are usually a result of baseball injuries. The ball hits the end of the finger, suddenly and forcibly flexing the distal phalanx. The extensor tendon is torn from its insertion at the base of the distal phalanx, carrying a small fragment of bone with it. (Fig. 160.) The patient is unable to extend the distal phalanx of the injured finger. Such a condition is known as a baseball or mallet finger. A comparable injury on the volar surface occurs if the distal phalanx is suddenly and forcibly hyperextended (instead of flexed). If the avulsion is on the dorsal surface of the phalanx, the finger is immobilized in a plaster cast, with the distal phalanx hyperextended. This relaxes the extensor tendon and allows healing

without a permanent "drop" to the phalanx. An avulsion fracture of the volar surface is immobilized with the finger flexed. At times the avulsed tendon is sutured as the treatment of choice. The period of immobilization in this fracture is an exception. The finger is immobilized for three to six weeks. During the latter part of the treatment, the splint is removed for progressively longer periods each day.



Fig. 160.—"Baseball finger." The extensor tendon of the distal phalanx has avulsed a fragment of bone. Thus active extension of the terminal phalanx is lost. Note *droop* of the distal phalanx.

Dislocations.—Dislocations frequently occur at the proximal interphalangeal joint. The distal portion is usually dislocated onto the dorsum of the proximal phalanx. The dislocation is reduced by exerting traction on the distal fragment in line with the proximal fragment. Immobilization is carried out with the dislocated joint in a flexed position. It is well to remember that the tendons and the capsule of an interphalangeal joint at times grasp the neck of the phalanx in the dislocated position. Under such circumstances, manipulative reduction may be impossible. The finger should be immobilized for seven to ten days only, since a longer time only increases the chance for stiffness.

After the cast or splint is removed in a fracture or dislocation of the phalanges, it is important to institute physical therapy to obtain good motion in the fingers.

In filling out an insurance form in a fracture of the phalanges, the practitioner should estimate the total disability at four weeks and partial disability at two additional weeks. Under "Anticipated Loss" he may note that stiffness in the phalanges is common.

In filling out an insurance form in a dislocation of the phalanges, the practitioner should estimate the total disability at two weeks and partial disability at one additional week. Under "Anticipated Loss" he may note that persistent periarticular swelling and disabling stiffness in the fingers are common following a dislocation.

Metacarpals Except That of the Thumb

Fractures of the metacarpals are often due to fist fights. There are two sites at which the fracture commonly occurs. The first site is the distal portion of the metacarpal shaft just proximal to the rounded and expanded head. The distal fragment, composed of the head of the metacarpal, is usually displaced volarward into the palm. Hence, clinically, there is an absence of the normal prominence of the knuckle on the dorsum of the hand. Furthermore, if healing occurs, with the original deformity uncorrected, a severe disability results. When the patient attempts to grasp, he has the sensation of an object interposed between his hand and whatever he is grasping. Consequently, good reduction is important in this type of fracture. Reduction may be effected by flexing the finger acutely at the metacarpophalangeal joint and then exerting a force toward the dorsum of the hand, using the phalanx as a lever. The finger is immobilized in a plaster cast while it is flexed acutely at the involved joint. Pressure is thus continued toward the dorsum of the hand. In this way the phalanx tends to prevent the metacarpal head from slipping again into the palm. Because stiffness in the metacarpophalangeal joint often follows treatment by this method, we advise an alternative method. After reduction by manipulation, a Kirschner wire is inserted through the head of the adjacent normal metacarpal and through the head of the fractured metacarpal. Then a cast is applied, incorporating the Kirschner wire. In this manner, the wire acts to maintain the position of reduction, and it is unnecessary to keep the finger acutely flexed as in the first method of treatment.

The second common site of a fracture of the metacarpal is the shaft, and the fracture may be transverse or oblique. After correct alignment has been obtained, the part is immobilized, using either one of two methods. A straight dorsal splint, which extends along the dorsum of the forearm, wrist, and fingers, can be applied. If this method is used, the splint is usually cut back progressively during the ensuing two to four weeks so that the fingers are allowed increased mobility. This precaution is important because stiffening of the phalanges may result if immobilization on a straight splint is continued very long. In another form of immobilization, commonly used as an alternative to the straight dorsal splint, a roll is placed in the palm of the hand, and the fingers are placed in a "grasp" position over the roll. Then a straight volar splint is applied. Another excellent method of splinting a fracture of the shaft of a metacarpal is to use a molded plaster volar splint well shaped in the palm. An oblique

without a permanent "drop" to the phalanx. An avulsion fracture of the volar surface is immobilized with the finger flexed. At times the avulsed tendon is sutured as the treatment of choice. The period of immobilization in this fracture is an exception. The finger is immobilized for three to six weeks. During the latter part of the treatment, the splint is removed for progressively longer periods each day.



Fig 160 —"Baseball finger " The extensor tendon of the distal phalanx has avulsed a fragment of bone Thus, active extension of the terminal phalanx is lost. Note *droop* of the distal phalanx

Dislocations.—Dislocations frequently occur at the proximal interphalangeal joint. The distal portion is usually dislocated onto the dorsum of the proximal phalanx The dislocation is reduced by exerting traction on the distal fragment in line with the proximal fragment. Immobilization is carried out with the dislocated joint in a flexed position. It is well to remember that the tendons and the capsule of an interphalangeal joint at times grasp the neck of the phalanx in the dislocated position. Under such circumstances, manipulative reduction may be impossible The finger should be immobilized for seven to ten days only, since a longer time only increases the chance for stiffness.

After the cast or splint is removed in a fracture or dislocation of the phalanges, it is important to institute physical therapy to obtain good motion in the fingers.

diagonally across the midportion or waist of the bone (Fig. 161), with the result that the blood supply to one fragment is frequently interrupted. Hence, *nonunion and aseptic necrosis* are especially to be kept in mind as possible complications. Consequently, the wrist should be immobilized for nine weeks even though this is an unusually long time for a bone of this size. The cast is applied with the wrist in hyperextension (cock up), with radial deviation of the hand, and with the thumb in wide abduction. In this position the fragments tend to be compressed together, and thus the tendency toward nonunion is diminished Nonunion of a fractured carpal scaphoid is likely to result in a painful, weak wrist, *with a concomitant limitation of motion.*

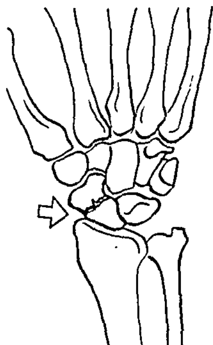


Fig 161.—Fracture of the carpal scaphoid This fracture is often not visualized at first. "Sprained" wrists which remain symptomatic for two weeks should have repeat roentgenograms taken *with the wrist in ulnar deviation.*

There are four main methods of treating nonunion. In the first method, a cast is applied for several months until union occurs; in the second, the site of the nonunion is exposed operatively, and a small bone graft is inserted across the gap; in the third, the scaphoid is excised; and in the fourth, the scaphoid is replaced by a Vitallium mold the size and shape of the bone. A caution should be expressed in regard to the last two methods, inasmuch as the incidence of weakness, pain, and limitation of motion after such procedures is said to be high. In the treatment of nonunion we first advise the application of a cast for several months in an attempt to obtain union. If nonunion persists, then a bone graft procedure appears to be the method of choice.

In filling out an insurance form in a fracture of the carpal scaphoid the practitioner should estimate the total disability at fourteen to sixteen weeks

fracture may need open reduction or skeletal traction to prevent overriding. Open reduction or skeletal traction (using a banjo splint) can be used if reduction and splinting as just described are unsuccessful in obtaining satisfactory alignment. Occasionally it is better to perform an open reduction and insert a Kirschner wire throughout the length of the medullary canal.

In a metacarpal fracture the finger should be immobilized for about four weeks. Progressively more freedom should be allowed for the finger down to the metacarpophalangeal joint to avoid joint stiffness.

If malunion at the metacarpal neck occurs in such a way that the metacarpal head is projected into the palm, a surgical procedure can be used in correction. After the neck is osteotomized, the head is replaced on the shaft in good alignment. Then treatment is the same as for a fresh fracture.

Metacarpal of the Thumb

Fractures of the metacarpal of the thumb are somewhat different from the others. Bennett's fracture is common in unskilled fist fighters. The fracture is oblique, occurs at the proximal portion of the first metacarpal, and is so placed that it involves the carpometacarpal joint. Reduction is carried out by swinging the thumb into wide abduction and exerting pressure toward the midline at the proximal end of the metacarpal. A cast is then applied while this position is held. At times, there is so much comminution of the joint surface that either resection of the proximal metacarpal or arthrodesis should be seriously considered. If manipulation is successful in obtaining a good position, traction can be used. The prognosis in Bennett's fracture is somewhat worse than in other fractures of the metacarpals. Healing in deformity is common because of the difficulty in maintaining reduction even after it has been obtained. Since a joint surface is involved, a painful arthritis may follow later.

In filling out an insurance form in fractures of the metacarpals in general the practitioner should estimate the total disability at six to eight weeks and partial disability at an additional two to four weeks. Under "Anticipated Loss" he may note that disabling stiffness in the metacarpophalangeal joints is common.

Carpus

The carpal scaphoid and the carpal semilunar are the two bones in the carpus most likely to be injured The scaphoid bone is prone to be fractured and the semilunar to be dislocated. Fractures of the carpal scaphoid are common, while dislocations of the semilunar bone are not especially common but perhaps occur more often than any other injury of the carpus except fracture of the carpal scaphoid. The other fractures and dislocations of the carpal bones are so rare that they do not require specific comment here

Fractures of the scaphoid are classically manifest by tenderness in the anatomic snuffbox on the dorsoradial aspect of the wrist. Since the carpal scaphoid is relatively superficial at this location, tenderness in the anatomic snuffbox should always lead to a strong suspicion of a fracture. The fracture line usually passes

After reduction, a sugar tongs cast is applied with the wrist in moderate flexion and in ulnar deviation. It should be emphasized that the flexion should be only slight to moderate—not acute. There are specific reasons for the position of flexion and the ulnar deviation. Flexion tightens the tendons and ligaments on the dorsum of the wrist and thus continuously counteracts the tendency for the distal fragment to slip dorsally, and it maintains the normal angulation of 15 degrees volarward. Ulnar deviation forces the ulnar styloid back into place and aids not only the reduction of this fragment, but also its healing. Furthermore, ulnar deviation maintains the normal angle between the radial and ulnar styloids (counteracting the tendency of the deformity of radial deviation of the hand).

The fracture is immobilized for four weeks in a child and for five or six weeks in an adult. During the latter part of the immobilization, the dorsum of the sugar tongs cast is raised, and physical therapy is instituted in the form of heat, massage, passive motion for the wrist, and active motion for the fingers. It is to be emphasized that the sugar tongs cast extends only to the metacarpophalangeal joint, and the patient is urged to exercise the fingers frequently during the weeks the cast is on. Otherwise, stiffening of the fingers may result.

Since fractures of the distal radius are exceedingly common, they should be well understood.

Colles' Fracture.—The classic Colles' fracture is a transverse fracture of the distal radius. Treatment in such a fracture consists of manipulative reduction as just described (hyperextension of the distal fragment, traction, and then flexion) and the application of a sugar tongs cast with the wrist in slight to moderate flexion and in ulnar deviation.

Comminuted Fracture.—Comminuted fractures of the distal radius with dorsal displacement or angulation are common. A comminuted fracture often extends into the wrist joint. Treatment may be varied somewhat. Under these circumstances, absorption and collapse of the comminuted distal fragment sometimes occur. Hence, a Kirschner wire can be inserted into the shaft of the second and third metacarpals transversely and allowed to protrude. Then reduction by conventional manipulation is carried out. A circular cast (rather than a sugar tongs cast) is applied from the elbow down over the wrist (held in flexion and ulnar deviation) and incorporates the Kirschner wire. In such a manner, the Kirschner wire maintains the hand and the wrist in the desired position, and collapse, with radial deviation of the hand, is not so likely to occur.

Fracture of the Epiphyseal Plate.—This fracture, which is through the distal *epiphyseal plate* of the radius, occurs in children. The distal radial epiphysis is displaced dorsally. Treatment consists of manipulation by hyperextension of the fragment, traction, and then flexion, which are usually successful in obtaining reduction. However, since a growing center is concerned, excellent reposition of the fragments is essential. Open reduction is used if manipulation fails.

Incomplete Fracture.—Incomplete fracture of the distal radius (such as the greenstick fracture and infraction) occurs in children. In treatment it can be reduced by manipulation in the conventional manner, and a sugar tongs cast

and partial disability at an additional four to six weeks. Under "Anticipated Loss" he may note that nonunion and aseptic necrosis are common, with resultant prolonged disability and permanent partial loss of function.

The semilunar bone is ordinarily dislocated toward the palm. In order to reduce the dislocation it is necessary to open up the space formed by the scaphoid radially, the capitate distally, the hamate medially, and the radius proximally. Hyperextension of the wrist does just this. Then by exerting pressure upon the semilunar on the palmar surface directed toward the dorsum of the hand, reduction is accomplished. A cast is applied with the wrist in flexion so as to close the space on the palmar aspect of the semilunar bone, thus counteracting any tendency toward redislocation. Immobilization is continued for two weeks.

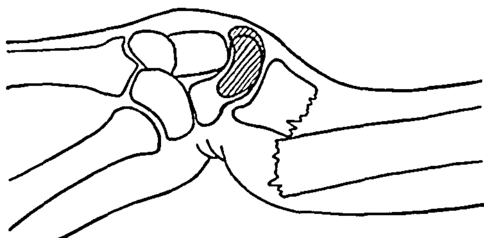
In filling out an insurance form in a dislocation of the semilunar bone the practitioner should estimate the total disability at four weeks and partial disability at an additional two weeks. Under "Anticipated Loss" he may state that none is anticipated

Distal Radius and Ulna (Colles' Fracture)

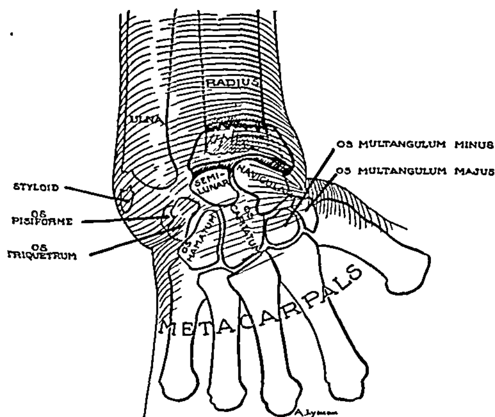
Colles described a very specific type of fracture of the distal radius. However, the term Colles' fracture is now used loosely to cover almost all fractures of the distal radius and ulna.

The fracture is sustained by a fall upon an outstretched hand and wrist. The fracture line passes transversely across the distal radius, and the ulnar styloid may be avulsed. The distal fragment of the radius is displaced dorsally, resulting in a silver fork deformity. There is a loss of the normal angle between the radial and ulnar styloids and of the normal angle at which the radial articular surface faces volarward. In other words, the hand has swung from its normal ulnar deviation into radial deviation, and the wrist has been projected dorsally. To understand the correct treatment of such a fracture, it is necessary to consider a few very important normal anatomic angles (Fig. 162, *A-F.*) In the anteroposterior plane, the radial styloid projects distal to the ulnar styloid so that a line connecting the two styloids makes, on the average, an angle of 25 degrees with a line drawn directly across the radius and the ulna (that is, perpendicular to these bones). This 25-degree angle is very important because the grasp is weakened if the hand is not held in a certain amount of ulnar deviation. The next important normal anatomic angle is that of the radiocarpal joint. The articular surface of the radius faces volarward on the average by 15 degrees from a perpendicular line to the dorsum of the radius Both of these angles should be reconstituted during a reduction.

Consequently, to reduce such a fracture, the distal fragment is grasped and hyperextended sharply in order to free it. Next, traction is applied to the fragment in the long axis of the forearm. This brings the fragment distal enough so that the third step, flexion of the distal radius, can be performed. Reduction can be judged roughly by noting whether the wrist passively flexes easily to about 90 degrees with the forearm, by palpating the styloids and judging the angle between them, and by palpating the dorsal surface of the radius to ascertain whether any deformity remains.



E.



F.

Fig 162 —(Continued)

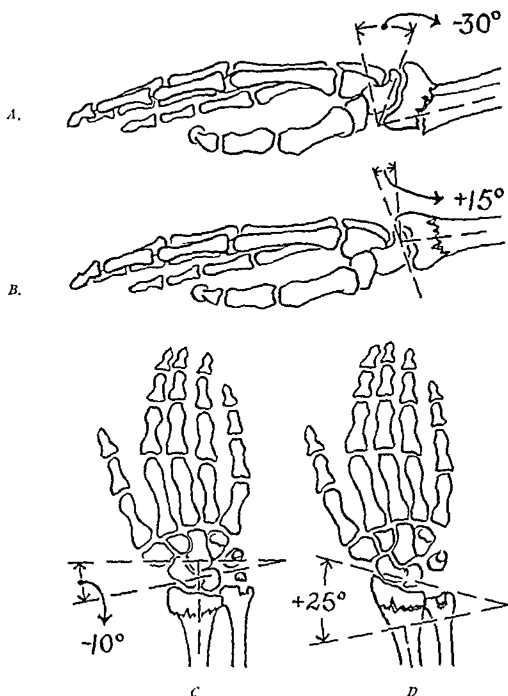


Fig. 162.—*A*, Lateral view of fracture of the distal radius. Note that the articular surface has been tilted dorsally by 30 degrees instead of facing volarward by 15 degrees. *B*, Lateral view of fracture of the distal radius following reduction. Note volvar inclination of the articular surface (normal average, 15 degrees). *C*, Anteroposterior view of fracture of the distal radius. Note radial deviation of hand and note that the ulnar styloid is actually distal to the radial styloid. *D*, Anteroposterior view of fracture of the distal radius. Note the normal position of the radial styloid distal to the ulnar styloid. *E*, Colles' fracture. *F*, Colles' fracture. (*E* and *F* from Larson, C. B., and Gould, M.: Calderwoods' Orthopedic Nursing, 1957, The C. V. Mosby Co.)

anatomic reposition of the fragments can be accomplished by manipulation, but occasionally it cannot. If satisfactory alignment cannot be obtained by closed means, operative replacement is indicated. The notable complications in distal radial epiphyseal separation are premature fusion of the epiphysis and progressive deformity due to incomplete reduction. As a result of fracture of the epiphyseal plate, growth may cease. Under such circumstances the ulna continues to grow, and the hand is carried into a deformity. It is wise to advise the patient's family about these possibilities when dealing with this type of fracture.

In filling out an insurance form in a fracture of the distal radius and ulna, the practitioner should estimate the total disability at eight to ten weeks and partial disability at an additional two to four weeks. Under "Anticipated Loss" he may note that usually no loss of function is anticipated but that various late sequelae may develop.

Distal One Third of Radius and Ulna.—In children particularly there occurs occasionally a fracture of the radius or of the radius and ulna that is situated about half way between the site of the usual Colles' fracture and the site of fractures of the midshafts of both bones of the forearm; that is, the fracture occurs at the junction of the distal one third and the proximal two thirds of the radial shaft. Usually it can be reduced by manipulation. However, recurrence of the original deformity is more likely to take place at this site than in a fracture of the distal radius. Consequently, instead of using a sugar tongs cast for immobilization, it is recommended that a circular plaster cast be applied. The cast should extend from the midhumerus, over the flexed elbow, and over the forearm and as far as the metacarpophalangeal joints.

The reasons for mentioning this fracture specifically are the greater tendency for a recurrence of the deformity and the need for a different type of cast.

In filling out at insurance form in a fracture of the distal one third of the radius and ulna, the practitioner should estimate the total disability at ten to twelve weeks and partial disability at an additional two to four weeks. Under "Anticipated Loss" he may note that no loss of function is anticipated.

Post-Traumatic Median or Ulnar Nerve Paralysis

The median and the ulnar nerves supply the motor fibers to the intrinsic muscles of the hand. Either or both of these nerves may be severed by lacerations of correct location on the volar aspect of the forearm, wrist, or palm. Therefore the practitioner should test the power and activity of the hand following lacerations in these locations. A complaint of inability to oppose the thumb to the index finger by a patient suffering an acute laceration raises the possibility of damage to the median nerve. A complaint of inability to flex the fingers, especially the fourth and fifth at the metacarpophalangeal joints (while maintaining the interphalangeal joints extended), poses the possibility of damage to the ulnar nerve The patient may complain also of weakness in the hand after an injury. Sensory loss of the median nerve is found on the volar aspect of the thumb, index finger, middle finger, and one half of the ring finger. Therefore in fresh lacerations so situated that either the ulnar or median nerves might be

is applied. Some orthopedists do not attempt reduction of greenstick and infraction fracture, feeling that they cannot or need not be reduced. We disagree with this attitude.

Smith's Fracture (Reversed Colles' Fracture).—In this fracture the reverse of the usual fracture occurs, with the distal radius displaced volarward instead of dorsally. It is reduced by manipulations which are the reverse of those used in a Colles' fracture. The affected part is immobilized with the wrist in extension (instead of in flexion as in a Colles' fracture) and in ulnar deviation (the same as in a Colles' fracture).

Some of the complications of fractures of the distal radius and ulna are malunion, nonunion of the ulnar styloid, arthritis of the distal radioulnar joint, premature fusion of the distal epiphysis of the radius, progressive deformity due to incomplete reduction of a fracture through the epiphyseal plate, and rupture of the extensor pollicis longus.

Malunion occurs if the distal radial fragment was not sufficiently flexed at the time of reduction; that is, the reduction was not complete. The condition is manifest by a persistent dorsal deformity and by inability to flex the wrist to a normal degree. Sometimes, there is absorption at the fracture site in spite of a good reduction, and the hand is swung into more radial deviation than is normal. This type of malunion leads to a readily apparent deformity and to a weakening of the grasp. Treatment in malunion is surgical. The dorsolateral aspect of the radius is exposed, and the site of the malunion is osteotomized. The distal fragment is then placed in the proper amount of volar flexion and ulnar deviation. The open wedge thus created is packed with bone chips in order to maintain the position of correction. A cast is applied and treatment as in a bone graft is carried out. It is apparent that both the deformities of dorsal tilt or displacement and of radial deviation are corrected by the same procedure.

Nonunion of the ulnar styloid may result in a painful wrist (though not necessarily so). Nonunion might occur because adequate ulnar deviation was not obtained at the reduction or it might be due to a loss of the blood supply between the ulna and the avulsed fragment or to interposition of a ligament between the fracture surfaces. However, it is well to attempt to obtain good ulnar deviation at the time of reduction in order to avoid nonunion. If a painful wrist develops because of nonunion of the ulnar styloid, the ununited fragments may be excised

At times, painful arthritis develops at the distal radioulnar joint following fracture of the distal radius If the condition is disabling, resection of the distal ulnar shaft, including the styloid and the region of the joint, is carried out.

Not uncommonly a child (with the distal epiphysis not yet fused to the radius) falls upon an outstretched hand and wrist and sustains a fracture through the epiphyseal plate. The epiphysis is carried dorsally exactly as described in Colles' fracture. In this situation a very good reduction should be insisted upon, inasmuch as a center of bone growth is involved. In almost all cases

normal control subject. Stiffness may be quite apparent in the hand, and the patient may complain of the stiffness as well.

A cervical sympathetic block can be performed, as both a diagnostic and a therapeutic measure. During an active, successful cervical block the patient may find that the sweating stops, that the temperature and color return to normal, that the pain disappears, and that the mobility of the fingers increases, and there may be a loss of the sensation of stiffness. This state may last for twelve to twenty-four hours or longer. If this is the case, the practitioner should assume that the condition is a reflex sympathetic dystrophy involving the hand.

Treatment may consist of several sympathetic blocks of the cervical region, and if relief is obtained from each block and lasts for a progressively longer period, it might be possible to bring the condition under control by a series of repeated blocks alone. However, if relief is temporary only, consultation should be held with regard to performing a dorsal sympathectomy. Consultation should be held early, inasmuch as the eventual prognosis depends upon the rapidity and vigor of the treatment.

Delayed Rupture of the Extensor Pollicis Longus

If the patient complains of inability to extend the thumb, he should be questioned about a previous injury compatible with a Colles' fracture of the distal radius, since on rare occasion a rupture of the extensor tendon of the thumb occurs following a Colles' fracture. The rupture takes place several weeks after the fracture. Its cause is apparently attrition of the tendon over an area of roughening in the bone, which may be a residual deformity of the fracture.

Diagnosis is made by observing the inability of the patient to extend the distal phalanx of the thumb and the absence of the normal subcutaneous prominence made by the taut, active tendon. Treatment, of course, consists of suture of the ends of the tendon.

Post-Traumatic Osteitis (Kienböck's Disease and Preiser's Disease)

Kienböck's disease is the name given to post-traumatic osteitis of the carpal semilunar bone, and Preiser's disease designates the same pathologic change in the carpal scaphoid bone. Some have compared this condition to the osteochondritides, such as Legg-Perthe's disease, Kohler's disease, and Freiberg's infraction. Nevertheless, both Kienböck's disease and Preiser's disease occur in mature bone rather than in an epiphysis, are commonly seen after an injury, and probably are more nearly comparable with Kummell's disease of the spine. The presenting complaints are pain and swelling in the wrist following a previous injury. The diseases are manifest clinically by pain in the wrist and limitation of motion. The roentgenograms show sclerosis and rarefaction of the involved bone, with a distortion of the normal contour, which is crushed. Treatment may be conservative or radical. Conservative treatment consists of immobilizing the wrist in a "cock-up" position for several weeks. If the pain and disability are not thereby relieved, the carpal semilunar or scaphoid is excised.

severed, it is well to make the following observations: (1) whether the thumb can be actively and strongly placed into a position of opposition by the patient, (2) whether the fingers can be spread apart from one another and brought back together again by the patient, (3) whether the patient can flex the fingers at the metacarpophalangeal joints and yet maintain the interphalangeal joints extended, and (4) whether there is any sensory loss on the volar aspects of any finger, including the thumb. If either the median or the ulnar nerve is damaged, the treatment consists of suture of the freshly lacerated nerve by a physician with sufficient surgical experience to ensure optimum conditions in what may be an extremely difficult technical procedure.

It should be realized that some patients present themselves with a complaint of weakness in the hand some time after the laceration occurred. The patient may have sustained a cut and sought no treatment for it at the time. Several months afterward he may complain that it is awkward to button clothing (median nerve injury) or that the fourth and fifth fingers involuntarily assume a peculiar position (extension at the metacarpophalangeal joints and mild flexion of the interphalangeal joints—ulnar nerve injury). The physician may not discover the true situation (previous laceration, now healed) until examination of the hand reveals signs of ulnar or median nerve damage and until a scar is sought and the patient questioned *specifically in this regard*. Treatment in this type of injury is highly specialized.

Laceration, fresh or previous, is not the only basis for signs of median or ulnar nerve palsy. In certain occupations the patient may repeatedly press firmly upon the "heel" of the palm, such as in pushing wood through a power saw or power plane. Under such a circumstance the median nerve particularly may be subjected to forces within the carpal tunnel, resulting in a gradual and progressive onset of an eventual complete median nerve paralysis.

Application of a splint, protecting the "heel" of the palm from pressure, and carefully applied physical therapy aid recovery, which usually occurs without surgical intervention. At times it may be necessary to open the carpal tunnel to relieve the pressure on the nerve.

Reflex Sympathetic Dystrophy

There is a complaint of pain involving the wrist and hand after injury which may persist for some time without correct diagnosis. If a patient sustains an *injury, even of relatively minor degree, and continues to complain of pain which* is rather severe, involves in general the entire hand, and at times may be associated with pain in the shoulder, the practitioner should consider the diagnosis of reflex sympathetic dystrophy. Inspection reveals that the hand is somewhat cyanotic or has an unhealthy rubor and frequently is cool and sweats excessively as compared to the other hand. The hand in general may be tender to touch. At times there are features which are reminiscent of rheumatoid arthritis. The roentgenograms may reveal nothing more than osteoporosis. Temperature studies reveal that the affected hand is several degrees cooler under varying temperature conditions than is the opposite normal hand and the hand of a

conditions can in fact arise as a result of injury. When injury is not the prime factor, the doctor should think of such conditions as tenosynovitis, de Quervain's disease, snapping finger, Dupuytren's contracture, calcific bursitis, ganglion, arthritis, etc.

Tenosynovitis

Tenosynovitis of the extensor tendons of the dorsal aspect of the wrist and hand is common. This is probably due to the numerous repeated and strenuous actions required of these tendons by the many persons engaged in heavy labor. The patient complains of swelling of the wrist and metacarpals and pain upon moving the fingers. Clinically there may be a diffuse swelling over the dorsum of the hand, with poorly localized tenderness. Extension of the fingers against resistance causes pain along the involved tendons. The examiner usually finds a grating crepitus to palpation during active motion of the fingers by the patient.

Treatment consists of rest for the injured part and the application of heat. Rest can be obtained by using a small padded basswood splint or a molded plaster splint. Usually seven to ten days are required for the symptoms to subside.

This condition is an irritative, inflammatory process. Suppurative tenosynovitis, however, occurs occasionally. Such a process is accompanied by a systemic reaction, including an elevation in temperature to 103 or 104° F. and marked swelling, redness, heat, and tenderness over the tendons. Treatment in suppurative tenosynovitis consists of operative drainage and systemic chemotherapy.

De Quervain's Disease

If the patient complains of stiffness in the thumb and pain along the radial aspect of the distal radius when movement of the thumb is attempted, a special type of tenosynovitis which sometimes affects two tendons of the thumb should be suspected. The affected tendons are the abductor pollicis longus and the extensor brevis. The process is called de Quervain's disease or stenosing tenosynovitis. There may be a fusiform proliferation of scar tissue in the tendon which increases its size and also a constriction of the tendon sheath due to scarring. Hence, the tendon frequently gets caught within the sheath, and motion is thereby markedly limited. Pain and tenderness overlying the abductor pollicis longus and the extensor pollicis brevis, together with restricted motion so that flexion of the thumb is painful and limited, indicate the diagnosis.

Treatment is surgical for the most rapid relief. The tendon sheaths are simply opened to allow the tendons free motion. At times de Quervain's disease can be managed by immobilizing the thumb in a plaster cast for four to six weeks. If this method is used, caution should be exercised to avoid an increase in stiffness. The thumb should be allowed progressively more freedom after the first two or three weeks in a cast

Snapping or Trigger Finger

Snapping finger is another form of tenosynovitis The patient may complain that the finger jumps or snaps and is painful at the time of the "snap."

NONTRAUMATIC DISORDERS OF THE WRIST AND HAND

Complaint	Likely Diagnoses	Page
Swelling on dorsum of wrist and metacarpals with pain on motion of fingers	(1) Tenosynovitis	355
Stiffness in thumb and pain along radial aspect of distal radius upon attempted motion of thumb	(1) De Quervain's disease	355
Painful snapping of finger or thumb upon attempted flexion	(1) Snapping or trigger finger	355
Progressive loss of extension of fourth and fifth fingers	(1) Dupuytren's contracture	356
Painful, red swelling on volar aspect of wrist, ulnar side	(1) Calcific bursitis or tendonitis	356
Painful (sometimes painless) swelling on dorsum of wrist	(1) Ganglion	356
Painful, swollen, and stiff proximal interphalangeal or metacarpophalangeal joints	(1) Rheumatoid arthritis	357
Painful, swollen, and stiff distal interphalangeal joints	(1) Hypertrophic arthritis	357
Transient pain in fingers associated with pain and swelling in one or more large joints, together with elevated temperature	(1) Meningococcal arthritis, gonococcal arthritis, rheumatic fever	358
Pain and indolent, persistent swelling of wrist	(1) Tuberculous arthritis	358
Weakness in hand, especially in thumb	(1) Post-poliomyelitic weakness, especially opponens paralysis	358
Clenched hand	(1) Cerebral palsy (spastic paralysis)	359

A discussion of nontraumatic disorders of the wrist and hand will now be presented. It should be kept in mind that upon certain occasions some of these

be made by palpation of the rounded, rather firm, but somewhat rubbery, mass on the dorsum of the carpus, usually near the proximal ends of the second and third metacarpal bones. The roentgenograms are negative. A ganglion is a multilocular cystic structure containing a thick, glairy, pale yellow fluid (like joint fluid from which considerable water has been removed). The ganglion is connected by a stalk to a tendon, a tendon sheath, or a joint. The cyst can change shape, size, and firmness and at times can disappear entirely. The same ganglion is at times painful and at other times painless.

If the patient is experiencing considerable pain, the ganglion should be removed surgically, with care taken to trace and ligate the stalk. If the ganglion is of such a size as to interfer with function or to cause pressure on blood vessels or nerves, it should be removed. If the patient believes the swelling to be malignant and refuses reassurance to the contrary, excision is carried out. If the ganglion is neither painful nor disabling, the patient can simply be reassured with regard to its nature. The majority of patients are content to leave matters as they are after learning the nature of the lump on the wrist.

The practice of smashing the ganglion with a heavy book results mainly in making surgical removal exceedingly difficult when the ganglion recurs, as it does, in the form of many, many small cysts attached to all possible surrounding structures.

Recurrence is possible, of course, even when precise and adequate surgery has been performed upon a ganglion which was not subjected to the abuse of being smashed.

Rheumatoid Arthritis

Patients not infrequently complain of painful, stiff, and swollen fingers. Many times, a moment's glance is all that is needed to make the tentative diagnosis of rheumatoid arthritis. The typical fusiform swelling of the proximal interphalangeal joints, occurring in a bilaterally symmetrical pattern, is the classic sign of the disease Difficulty occurs, however, when the patient complains of pain of the proximal interphalangeal joints which show no swelling. The patient sometimes states that the fingers feel stiff, particularly upon arising in the morning, or points out that rings no longer slip readily over the proximal interphalangeal joints even though swelling is not apparent. However, a history of *steady pain* (as compared with the transient pain which occurs in certain other forms of arthritis, such as meningococcal or gonococcal) in the proximal interphalangeal joints and the metacarpophalangeal joints should cause the physician to consider rheumatoid arthritis most strongly and to inquire about other arthralgias affecting the large joints. See Chapter 12, Arthritis, (page 366) for a more complete discussion of the process and its treatment.

Hypertrophic Arthritis

A patient sometimes complains of painful, deformed, and stiff fingers, pointing out the *distal* interphalangeal joints (as compared with the *proximal*, as in rheumatoid arthritis) as the site of the difficulty. The likely diagnosis in this type of complaint is hypertrophic arthritis. Examination may reveal an en-

A rather common complaint is that the finger catches in flexion and that, in order to straighten it, it is necessary to pry it open with the other hand, with considerable pain. Pathologically the involved tendon has a fusiform swelling which can just squeeze through a constriction in the tendon sheath. The "snap" of the finger results as freedom of the tendon is gained after the enlargement has just passed through the constriction. The flexor tendons are particularly affected by this process so that as the patient attempts active flexion of the finger, the observer notes a sudden jump into a position of complete flexion. Conversely, as the patient attempts active extension from a flexed position, a sudden jump is noted. The examiner can palpate a tender enlargement of the flexor tendon usually just distal to the distal palmar crease.

Treatment can consist of operative release of the tendon. It is also possible to inject Hydrocortone into the involved tendon sheath to afford symptomatic relief. After such an injection and during the phase of subsidence of symptoms, a lesser degree of snapping can be palpated by the examiner. However, this snapping does not seem to be especially painful to the patient.

Dupuytren's Contracture

Dupuytren's contracture usually involves the fifth finger, although the other fingers are occasionally affected. The process is frequently bilateral, and there is a marked familial tendency. The presenting complaints are a progressive loss of extension in the fourth and fifth fingers. The fifth fingers slowly begin to bend or flex into the palm. Flexion occurs at the metacarpophalangeal joints and at each of the interphalangeal joints. Several months may pass before the fingers are completely flexed into the palm.

Apparently the palmar fascia is the contracting tissue. Nodules and firm contracting bands can be palpated from the middle of the palm distally into the contracted finger. The etiology is unknown, but a low-grade, chronic inflammatory process is seen in microscopic sections of the palmar fascia.

Excision of the palmar fascia is the indicated treatment.

Calcific Bursitis or Tendonitis

Rather infrequently a patient may complain of pain, redness, and swelling on the volar and ulnar aspects of the wrist about in the position of the pisiform bone. When a physician encounters this condition for the first time, he is likely to believe that he is dealing with an early boil. Yet the appearance is not truly that of such a process The roentgenograms reveal a small collection of calcium in the area of redness and swelling. Treatment consisting of x-ray therapy, ice bags, rest for the part, and narcotic medication, just as in acute calcific bursitis of the shoulder, appears to be successful in readily controlling the symptoms.

Ganglion

A very common complaint with regard to the wrist is a localized swelling on the dorsal surface. Sometimes pain is complained of as well, and sometimes the swelling follows an acute injury. The diagnosis is simple and usually can

pose the thumb to each of the other fingers is common after anterior poliomyelitis and represents a grave functional loss to the hand as a whole.

Several operative methods of correction consisting of tendon transference are available. They should be performed only by those especially skilled in this particular field.

Cerebral Palsy (Spastic Paralysis)

It is surprising how often the chief complaint of a clenched hand is made by a person in whom the chief complaint should regard the total locomotor, emotional, and developmental pattern of the patient. Therefore, if the patient complains of a clenched hand, the physician should, of course, inquire and examine with the thought in mind that cerebral palsy is the likely diagnosis. See Chapter 1, Diseases or Affections in Childhood, (page 13) especially the discussion on Cerebral Palsy (page 111).

larged distal interphalangeal joint, and one spot on the side of the joint may be red, swollen, and acutely tender to touch. Such a reaction is probably caused by an irritative lesion of the soft tissue occurring in association with the formation of a bony spur. The "lumps" on the sides of the hypertrophic distal interphalangeal joint are called Heberden's nodes and represent bony spurs. A patient presenting with the complaints just described may very well also have had previous experience with pain in one or more large joints. Conversely, pain in a large joint in a patient with deformed *distal* interphalangeal joints suggests that the likely diagnosis is hypertrophic arthritis. See Chapter 12, Arthritis (page 366) for a general discussion of the condition.

Meningococcal Arthritis, Gonococcal Arthritis, and Rheumatic Fever

If a patient complains of pain in the fingers, associated with pain and swelling in one large joint, several likely diagnoses are possible. In particular it is of importance to note whether the pain in the small joints has been *transient* and whether the patient appears to be systemically ill, with an elevation in temperature to septic proportions (not the low-grade elevation of temperature in rheumatoid arthritis). If there is a swollen, reddened, hot, painful large joint, if the patient has an elevated temperature, and if there is a history of *transient* pain in the fingers during the preceding two weeks, the most likely diagnoses are meningococcal arthritis, gonococcal arthritis, and rheumatic fever. We have hitherto amply pointed out that such diagnoses should not be considered until acute suppurative arthritis due to staphylococcus or streptococcus has been excluded. Yet transient pain in the small joints of the hand within the preceding two weeks occurs often in meningococcal arthritis, gonococcal arthritis, and rheumatic fever but not in arthritis due to staphylococcus and streptococcus. See Chapter 12, Arthritis, (page 366) for a complete discussion. These conditions are mentioned here only because at times the main complaint in these diseases involves the fingers

Tuberculous Arthritis

A complaint of a persistent nonreddened swelling and pain in the wrist, especially in the absence of arthralgia elsewhere, stigmas of rheumatoid arthritis, and a history of injury, should indicate a diagnosis of tuberculous arthritis. The roentgenograms help in establishing the nature of the process. See Chapter 12, Arthritis, (page 366) for a discussion of tuberculous arthritis and its management.

Post-Poliomyelitic Weakness, Especially Opponens Paralysis

Ordinarily, patients who have suffered an attack of anterior poliomyelitis sufficiently severe to leave residual paralysis of a significant function are aware of having had the disease. Therefore there is not much need for considering several different likely diagnoses when a patient who states that he has had *anterior poliomyelitis* presents with the complaint that he is unable to move the thumb properly. Paralysis of the thumb or weakness in the ability to op-

haversian canals. (2) Instead of dissecting up the periosteum, the abscess may perforate the cortex and periosteum and present itself as a soft-tissue abscess. (3) The suppurative process may pass from the cancellous bone of the metaphysis, breaking directly into the large general medullary cavity. (4) The pus may enter the neighboring joint directly, particularly if the metaphysis is intracapsular. (5) The original focus in the metaphysis may develop toward the epiphysis and enter the growing center. However, the epiphyseal cartilage is ordinarily a good barrier. Surrounding the osteomyelitic area there is a zone of thrombophlebitis. From the phlebitic foci, organisms may be fed back into the systemic circulation to continue or aggravate the septicemia or to set up

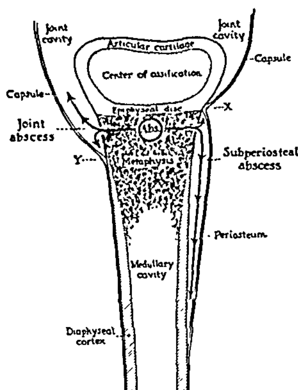


Fig 163.—Diagram to illustrate some possible pathways of the spread of the purulent material in acute hematogenous osteomyelitis. Y represents the situation when the metaphysis is intracapsular. Acute suppurative arthritis results, of course, when the infected material drains directly into the joint under such a circumstance. (From Hart, V L.: J. A M. A. 108: 524, 1937.)

secondary foci of osteomyelitis in other bones (metastasis). In the neighboring areas of the suppurative processes, certain pieces of bone, having been deprived of their circulation, undergo necrosis These necrotic fragments are called sequestra. New bone proliferates in the area of the inflammation and may ensheath the sequestra. (Fig. 164.) This latter process is called involucrum formation. The sequestra may be extruded through small openings in the bone called cloacae.

It should be clear from this description that the infection in the bone, however dramatic, is only an incident in a systemic disease—septicemia. The septicemia may be mild or severe and, if it is severe, may lead to pyemia, with

Chapter Eleven

Acute and Chronic Osteomyelitis and Brodie's Abscess

Acute Hematogenous Osteomyelitis

Acute hematogenous osteomyelitis is an acute suppurative lesion of the bone caused by one or another of the common pyogenic organisms. These organisms lodge in the bone as a result of a transient or, at times, more sustained septicemia.

There are three types of acute hematogenous osteomyelitis: that occurring in infants, that prevalent between 2 and 20 years of age, and that occurring after 20 years of age. Each type is distinct. Infants suffer from a disease caused, in 60 per cent of the cases, by hemolytic streptococcus. In the remaining 40 per cent the disease is caused by mixed infections—pneumococcal, typhoidal, etc. Patients between 2 and 20 years of age reveal hemolytic staphylococcus as the etiologic agent in approximately 90 per cent of the cases. In infants the bone is soft, is quickly destroyed by the infection, and is easily absorbed, while new bone is readily laid down. The suppurative process perforates the bone and a soft tissue abscess forms. On the other hand, in the childhood group (2 to 20 years of age), the infection is more poorly tolerated, and the bone is not so easily perforated nor so easily reconstructed. The adult type differs from the two others in that its onset is insidious rather than sudden, taking two to three weeks to develop. It more usually involves flat bones, such as the pelvis, skull, ribs, and vertebrae, rather than the long bones, as in infants and children. If the infection does involve tubular bones, it is more likely to affect the diaphysis than the metaphysis.

The pathogenesis of acute hematogenous osteomyelitis is as follows: Organisms invade the blood stream from a boil on the skin, a sore throat, or a break in the skin with a surrounding area of cellulitis. They are carried to the metaphysis of the bone where the circulation is inclined to be stagnant. At this site a cellulitis develops, and eventually suppuration, with destruction of the bone, occurs. (Fig. 163.) The abscess may progress in several ways: (1) It may perforate the cortex and come to lie beneath the periosteum. If this happens, the periosteum is dissected off the shaft by the purulent material, and the entire diaphysis, bathed in pus, may be infected by a reinvasion through the

Rheumatic fever involves many different joints and is migratory in nature. An examination of the heart should be made. However, a patient with acute, exquisite tenderness to bone palpation and an elevated temperature has acute hematogenous osteomyelitis until otherwise proved.

Treatment of the disease has passed through many phases. At one time there were two schools of thought. One believed that the disease should be treated by immediate operation to decompress the bone, and the other believed that the operation should be delayed until the infection had been brought under control after days of supportive treatment. It was true that early bone decompression offered the best chance for later integrity of the bone, but when early operation was performed upon a toxic or unprepared patient, the mortality rate was over 50 per cent. This was, of course, prohibitive. A toxic patient is one with a temperature over 102° F. or with a large number of recoverable organisms per unit of blood. Operation upon nontoxic patients offered a low mortality rate (around 3 per cent) and had better local results the earlier it was performed. On the other hand, delayed operation or conservative therapy carried a low mortality rate, but in about 90 per cent of the patients the disease progressed to chronic osteomyelitis. (See Fig. 164.) The complications in chronic osteomyelitis are exceedingly difficult to manage Some of the common ones are draining sinuses, sequestra, pathologic fractures, secondary infections, deformities, shortening of the limb, and limitation of motion in the neighboring joints.

It was hoped that the sulfonamides might solve the dilemma of the prohibitive mortality rate in early bone decompression and the complications in chronic osteomyelitis following conservative therapy. They did reduce the operative mortality to such a degree that early bone decompression could be done. Unfortunately, however, an attempt was made to treat the disease with the sulfonamides alone, without operation. The results of this method were worse than when early operation was performed on nontoxic patients without the use of chemotherapy. The major effect of sulfonamide therapy was the amelioration of the septicemic component of the disease. The sulfonamides have had no appreciable effect on the course of the infection in the bone.

After penicillin became available, many advocated treatment of this disease by penicillin alone, without bone decompression. If penicillin is used without operative intervention, the clinical course is as follows: Penicillin is administered intravenously or intramuscularly in large doses. The temperature course gradually falls by lysis over a period of two to three weeks. Subcutaneous collections of pus may develop; if they do, they are aspirated, and penicillin is introduced locally. The roentgenograms reveal areas of destruction of the bone and of new sclerotic bone formation which are indistinguishable from the clinical picture in chronic osteomyelitis. However, the process is probably not chronic osteomyelitis, in spite of its roentgenographic appearance. It is probably in the nature of aspeptic necrosis In the course of several ensuing months, "clearing" of the roentgenographic picture usually occurs so that no evidence of "chronic osteomyelitis" remains. Therefore, the difference between using penicillin combined with early operation or penicillin without operation is that, in the latter,

multiple hematogenous abscesses of the viscera, such as the liver, kidneys, and lungs. The general prognosis is largely dependent upon this septicemic phase of the disease.

The clinical picture for the largest group (the 2- to 20-year-old patients) will be presented here. The average age of the patient in this group is 11 years. During the week or two preceding the acute illness, the patient, usually a boy (60 per cent are males), has had either a boil on the skin or a sore throat and a cold. He may have injured himself slightly a day or two before the onset of the disease (a history of slight injury is elicited in about 40 per cent of the cases). The onset of the disease is sudden and is characterized by pain, usually described as being in the nearest joint (for example, the ankle, the knee, or the shoulder). The patient has an elevated temperature of from 101° to as high as 104° F., is restless and irritable, and may have vomited. Commonly, he is sweating profusely, if not, he is probably dehydrated.



Fig 164 —Chronic osteomyelitis of the tibia Note destruction of the bone, the sequestrum, and the proliferation of new bone.

Examination reveals that the joint complained of can be moved gently without pain but that the neighboring long bone is exquisitely tender to palpation This tenderness ordinarily is greatest in the region of the metaphyses. A slight erythema and swelling may be noted. At this stage of the disease, the roentgenograms are of no help in establishing the diagnosis. They do not show destruction of the bone until around the tenth to the fourteenth day after the onset of symptoms. Therefore, the diagnosis must be made clinically. The diseases to be distinguished especially are suppurative arthritis, cellulitis, and rheumatic fever. Ordinarily, the suppurative joint cannot be moved passively, even very gently, without exquisite pain Cellulitis shows a much more diffuse and indurated area than does an underlying osteomyelitis, and lymphangitis and lymphadenopathy are more prominent in cellulitis than in osteomyelitis.

The roentgenograms show that much of the metaphysis and diaphysis is involved in a destructive and sclerotic process. (See Fig. 164.)

In the treatment of such a condition, excision of as much diseased bone as possible has been done. In the Orr method the bone is saucerized, the soft tissue is refreshed, all the scar tissue and sinus tracts are excised, the wound is left open and packed with petrolatum gauze, a cast is applied, and the wound is disturbed as little as possible while it heals by secondary intention. Saucerization is carried out by drilling several holes in the form of a long oblong and connecting these holes by excision with an osteotome. Then the diseased bone is lifted out. The edges are smoothed off so that no overhanging shelves of bone remain. Some close the wound tight after the saucerization and administer enormous doses of the antibiotic to which the infecting organism is sensitive. The methods described are not uniformly successful, but in some patients they have proved to be of great value. As a general principle it can be remembered that the surgical excision of large areas of infected bone, combined with massive doses of an antibiotic, is responsible for the alleviation of symptoms in a certain percentage of the patients.

Brodie's Abscess

Brodie's abscess perhaps results when the resistance of the patient is high and the virulence of the infecting organism is low. Thus, it could be postulated that a patient might have an attack of acute hematogenous osteomyelitis from an organism so weak that the average clinical course of the disease was not followed. There would result a small, well-localized, and thoroughly walled-off, area of bone destruction containing pus which would ordinarily reveal no organisms.

Brodie's abscess is situated near the ends of the long bones. It is usually asymptomatic and is found accidentally when the region is x-rayed for some other reason. The roentgenograms show a small area of rarefaction surrounded by a rim of increased density—sclerotic bone. Occasionally Brodie's abscess gives rise to aching pain in the affected region Rarely have organisms been cultured from the pus, which, as previously stated, is ordinarily sterile.

bone changes develop which are indistinguishable on the roentgenogram from those of chronic osteomyelitis.

Consequently, a rational treatment in acute hematogenous osteomyelitis is as follows. The patient is sedated, using codeine and aspirin, and the extremity is splinted to reduce pain. Dehydration is combatted with infusions of saline and glucose, and supportive transfusions are given if necessary. The administration of penicillin is started intravenously and is continued intramuscularly. Under such treatment the patient is ordinarily ready for bone decompression within twelve hours, if decompression is to be performed. An incision is made over the region clinically known to be tender. Using a drill and osteotome, a cortical window is removed. A drain is placed in the wound, down to the bone. If there is early operation, frank pus may not be found, but a positive culture of the organism can be obtained from the marrow cavity.

Up to the present time, prognosis with regard to the healing of the bone and the wound has been directly dependent upon the time interval between the onset of symptoms and the operation. If the operation is performed within forty-eight hours after the onset of symptoms, healing occurs without recurrence in the majority of patients. If the bone decompression is done after the first week of the disease, healing occurs without recurrences in only about 10 per cent of the patients. This points to the wisdom of performing a bone decompression within the first week—the earlier the better, provided that the patient is prepared.

Streptococcal osteomyelitis in infants can probably be managed in the same manner as a soft-tissue abscess. Bone decompression is perhaps unnecessary. Penicillin is, of course, used as an adjunct. In the adult, treatment is modified according to the anatomic location of the involved bones.

Chronic Osteomyelitis

Chronic osteomyelitis presents a great number of problems. A patient with this disease gives a history of repeated exacerbations of pain, elevated temperature, formation of abscesses which break and form draining sinuses, etc. The sinuses may heal, and at a later date the patient again experiences pain and elevated temperature. Eventually a sinus will break down and exude purulent material or will point and break at some new site. Sometimes the sinus tracts never heal and continually drain infected material. Not infrequently, small pieces of bone are extruded from these sinuses as sequestra. A secondary infection caused by a virulent organism may gain a foothold in a sinus and result in a violent, acute illness which may end fatally. Shortening, or sometimes even lengthening, of the affected extremity results if the process involves a neighboring epiphysis. Limitation of motion of the nearest joint, or even ankylosis, is not uncommon as a result of suppurative arthritis if the previous suppurative process in the bone extended directly into a joint.

Previous acute hematogenous osteomyelitis is the basis, of course, for the development of a large percentage of cases of chronic osteomyelitis. Infected compound fractures or infected operative woulds are the cause in many other instances, as would be expected.

zation of the pain in a large joint. Anaerobic culture of the joint fluid may yield the gonococcus. The complement fixation test becomes positive later. Acute hematogenous arthritis does not ordinarily exhibit migratory pains involving multiple joints nor is there a urethral discharge. Meningococcal disease is not ordinarily difficult to distinguish from acute hematogenous suppurative arthritis. Except on rare occasions, the joint fluid usually reveals no organism on culture. Again, there frequently is a history of migratory arthralgia of the small joints. Furthermore, a skin rash is sometimes apparent in meningococcal disease but not in acute hematogenous suppurative arthritis. A clinical picture of cerebrospinal meningitis, of course, leaves no doubt as to the etiology of an acutely inflamed joint accompanying or almost immediately following the systemic disease. Ordinarily, central nervous system signs are not present in acute hematogenous arthritis. Tuberculous arthritis is diagnosed on the basis of the changes noted on the x-ray pictures, supported by the evidence from inoculation of a guinea pig with the joint fluid.

Osteomyelitis presents acute, localized bone tenderness, while the neighboring joint is slightly painful to gentle passive motion. In suppurative arthritis the nearby bone shows no tenderness to palpation. Cellulitis is distinguished by more induration, a diffuse spread, severe lymphangitis, and lymphadenopathy. Rheumatic fever is differentiated on the basis of a history of *migratory* arthralgia, negative results from the culture of the joint fluid, and examination of the heart. At times a therapeutic trial administration of aspirin is of diagnostic value. Again, it is pointed out that migratory arthralgia is not usual in acute hematogenous arthritis. It is safer first to presume that the diagnosis is septic joint and to exclude it before considering the diagnosis of rheumatic fever.

In the early stages of hematogenous suppurative arthritis the roentgenograms are not much help in diagnosis. They may show an effusion in the joint and sometimes a suggestion of bone atrophy.

It is apparent that an accurate clinical history is of great importance, that the joint should be aspirated, that the aspirated material should be examined microscopically, cultured, and injected into a guinea pig, and that a blood culture should also be taken. If the culture of the joint fluid reveals the infecting organism to be hemolytic streptococcus or hemolytic staphylococcus, the following pathologic process occurs. The synovium becomes thickened, edematous, and inflamed. A tense, purulent effusion forms within the joint, and the capsule is distended. Eventually, the articular cartilage becomes eroded and the bone is invaded. Fibrinous collections on the synovial surface come in contact with one another, bridging the joint. When these fibrinous strands become organized by granulation tissue, intra-articular fibrous adhesions form. If the articular cartilages are sufficiently eroded, so that raw bone approximates raw bone, then a true bony ankylosis may result.

Treatment is directed at overcoming the systemic infection in the blood stream and preventing the infection from persisting long enough to destroy the joint, either anatomically or functionally. There is a much greater uniformity of opinion with regard to the management of the systemic phase than there is with regard to the treatment of the affected joint. Supportive measures, such

Chapter Twelve

Arthritis

The term arthritis simply refers to an inflammation within a joint. When used without the proper qualifying adjectives, the term means relatively little. The following lesions will be considered here: acute hematogenous suppurative arthritis, gonococcal arthritis, meningococcal arthritis, tuberculous arthritis, hypertrophic arthritis, atrophic (rheumatoid) arthritis, gouty arthritis, and Charcot's joint or neuropathic joint.

Acute Hematogenous Suppurative Arthritis

In acute hematogenous suppurative arthritis, as in acute hematogenous osteomyelitis, it is possible during a transient or more sustained septicemia due to one of the common pyogenic organisms that the pyogenin may be deposited within a given joint Therefore, just as in acute hematogenous osteomyelitis, we are dealing with a severe systemic disease in which the lesion in the joint is simply *an incident* *It should be remembered that acute osteomyelitis and acute suppurative arthritis are frequently associated* Children are more commonly *affected than are adults, and the expected organism is a hemolytic staphylococcus* or streptococcus

Clinically, the child is acutely ill, with a temperature ranging from 102 to 104° F The onset is sudden, with a complaint of pain in a given joint. The large joints are the ones usually affected In addition to evidence of a severe systemic infection, examination reveals that the joint about which the patient complains is swollen, hot, red, tender to palpation, and exquisitely painful even to gentle passive motion

Differential diagnosis includes consideration of gonococcal infection, meningococcal disease (either meningococcemia or cerebrospinal meningitis), tuberculosis (since this may yield an acute picture), osteomyelitis, cellulitis, and *rheumatic fever* *Therefore, the history and microscopic examination and a* culture of the joint fluid are of paramount importance in making a correct diagnosis. *In gonorrheal arthritis there is a history of venereal contact within the* two or three weeks preceding onset and of a urethral or vaginal discharge. There may have been migratory pains involving the small joints previous to the locali-

tremities were placed in traction, and later passive motion was started. Likewise before the advent of chemotherapy (penicillin, etc.) Willems, in the treatment of the suppurative arthritis secondary to compound wounds of the joints (war wounds), drained the joint surgically, left the wound open, and began *active* motion within twenty-four hours after the operation. Weight-bearing was begun early, since he felt that active motion preserved the musculature and expressed purulent material from the various synovial recesses of the joint cavity.

Antibiotics have of course altered some phases of treatment of suppurative arthritis. At present, it is feasible to carry out the following program. The extremity is placed in traction on a splint so arranged that the patient may, by means of pulleys, exercise the affected joint passively. An aspirating needle is then introduced into the joint, and as much purulent material as possible is aspirated. Next, saline solution is injected into the cavity until the joint becomes tense, and then the saline solution is aspirated. Such injections and aspirations are continued for about fifteen minutes, and then the appropriate antibiotic is introduced directly into the joint. This procedure of joint irrigation and intracapsular administration of an antibiotic is carried out each day for as long as seems necessary. The duration can be determined by culturing the joint washings, observing the temperature course, etc. Around five days of treatment will usually suffice. Meantime, the antibiotic should be administered systemically. The passive motion which the patient himself carries out while the extremity is in traction is guided by how rapidly the arthralgia subsides. Physical therapy, active motion, and weight-bearing are started when, in the judgment of the physician, they are feasible.

If acute hematogenous suppurative arthritis is treated by evacuation of purulent material, either by operative drainage or multiple aspirations, and by sterilization of the joint cavity mechanically by saline solution and chemically by an antibiotic, and provided that treatment is begun reasonably early, the poor results attendant upon previous methods of treatment will be largely avoided.

Gonococcal Arthritis

Gonococcal arthritis previously led to bony ankylosis of the involved joint in a high percentage of cases. The gonococcus is very sensitive to penicillin and early treatment of gonococcal arthritis with penicillin prevents ankylosis.

The usual history is that of a young adult with a postcoital urethral or vaginal discharge who within two to three weeks after such an episode ordinarily experiences fleeting, migratory pains in the small joints of the fingers and wrists. A few days later the pain in the small joints may have subsided, but one of the large joints may be painful, swollen, tender to palpation, hot, and exquisitely painful on motion.

The organism is difficult to culture from the joint fluid but may be found in smears of prostatic or vaginal secretions. A complement fixation test *should* be made. It should be noted that the clinical history in gonococcal arthritis is similar to that in meningococcal arthritis, that is, both may begin with migratory arthralgia in the small joints, followed by a period of a few days of freedom from pain before one or two large joints become involved. There is no history

as infusions, transfusions, sedation, and administration of the antibiotic to which the organism has been found to be sensitive, are used to combat the septicemia. Many systems of treatment have been suggested in management of the affected joint. These systems have three main features in common: (1) evacuation of the purulent material from the joint, by either multiple aspirations with a needle or operative drainage; (2) the sterilization of the contents of the joint, either chemically or mechanically (ether, mercuric chloride, bismuth iodoform paraffin paste [BIPP], gentian violet, penicillin, etc. have been used to sterilize the joint cavity chemically; multiple flushings of the joint and repeated irrigations with saline solution are used to sterilize the joint mechanically); (3) immobilization of the joint or, conversely, allowing it motion. Many feel that to

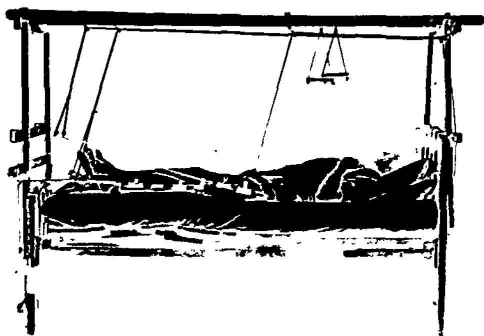


Fig. 165.—Traction and passive motion in joint infection (From Larson, C B, and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C V. Mosby Co)

immobilize an infected joint after drainage and sterilization (according to the first two principles) is the best way to quiet the infection and preserve movement in the joint. Thus, a plaster cast is frequently applied. Others believe that traction applied to the involved extremity (Fig. 165), so that passive motion can be given occasionally, combines the advantages of immobilization and preservation of movement. Still others believe that immediate active motion should be carried out after drainage.

Before the advent of antibiotics, Cotton advocated immediate surgical drainage of the joint. The joint was flushed out with saline solution for fifteen minutes (by the clock), and then the incision was closed, without drains. He felt that the synovium could successfully combat the infection if the pus was evacuated and the cavity was sterilized by mechanical lavage. Then the ex-

and several weeks may pass before the joint is normal. Physical therapy is begun as soon as the acute symptoms subside and is continued until a normal range of motion is assured.

Tuberculous Arthritis

Tuberculosis may attack the bones and joints. The hip, knee, and shoulder have, in the past, been the usual sites of tuberculous arthritis. Recently, a decline in this disease has accompanied the general decline in the incidence and severity of tuberculous infections as a whole. Tuberculosis of a joint is regarded as a secondary phenomenon; that is, it is secondary to pulmonary tuberculosis, gastrointestinal tuberculosis, or genitourinary tuberculosis (with which the joint disease is commonly associated).

Usually the disease manifests itself by gradually increasing pain and disability referred to a specific joint. Occasionally it is acute in onset and may even resemble acute hematogenous suppurative arthritis. However, the insidious onset is more common. There may be an indolent, persistent swelling in the region of the affected joint, with attendant atrophy of the surrounding musculature. The patient may complain of pain as a result of weight-bearing and active or passive motion and the development of a limp. Sometimes a history of night cry may be elicited from patients with tuberculosis of the hip.

The disease may start in the synovium, with the pathologic findings the same as those found in tuberculosis anywhere else in the body; that is, there is a chronic inflammatory response, with areas of caseation and giant cell formation. From the synovium the process spreads to involve articular cartilage, which becomes eroded, and eventually the subchondral bone is destroyed. Hence, the roentgenograms will show pericapsular soft tissue swelling, erosion of the joint surface which starts typically at the nonweight-bearing portion, atrophy of the bones entering the joint, and areas of destruction in this region, together with irregularity of the joint surface. It is obvious that such a pathologic process could easily lead to ankylosis. Occasionally, the caseous material forms into a cold abscess, dissects along the muscle planes, and may eventually break through the skin and produce fistulas.

A joint suspected of being tuberculous should be aspirated, and the aspirated material should be stained to determine the acid-fast organism and then injected into a guinea pig.

Clinically, then, tuberculous arthritis presents an insidious onset of a limp and pain and swelling around a joint. The diagnosis depends upon roentgenographic findings of destruction of the nonweight-bearing portions of the articular surface (Fig. 166), a positive result from the inoculation of a guinea pig with the joint aspirate, low-grade fever, the occasional development of fistulas, the finding of tuberculosis elsewhere in the body, and a positive skin test. It goes without saying that the lungs, the genitourinary tract, and possibly the gastrointestinal tract should be studied for evidence of the disease when tuberculous arthritis is discovered.

Treatment may be either conservative or radical In conservative treatment the affected joint is immobilized in a cast for many months. Needless to

of a urethral discharge in meningococcal disease, of course, and the central nervous system signs sometimes found in patients with meningococcal arthritis are lacking in those with gonorrheal arthritis. From a bacteriologic standpoint, the close relationship between the causative agents may explain the similarity of their clinical expressions. Pathologically, gonorrheal arthritis is similar to staphylococcal arthritis. There is the same propensity to destruction of the articular cartilage, to the production of fibrinous strands which become organized to form fibrous adhesions, and to bony ankylosis.

Treatment consists of the systemic administration of antibiotics, the intracapsular administration of the antibiotic of choice, the application of a splint to the affected extremity to prevent flexion contracture, and the use of physical therapy after the acute stage subsides.

Occasionally, chronic synovitis follows an apparent cure of the acute condition. Such chronic synovitis is characterized by exacerbations and remissions. The exacerbations consist of effusion and pain in the joint. The synovium is frequently boggy to palpation. Conservative treatment consisting of immobilization of the joint, application of a splint, and aspiration if the effusion is too tense is recommended. Should such conservative methods fail and if the disability warrants, a synovectomy is performed. Synovectomy, it should be remembered, is limited for practical purposes to the knee joint. See Chapter 4, Disturbances of the Knee in the Adult (page 191) for a discussion of the technique.

Meningococcal Arthritis

The joints may be involved during or slightly following a systemic invasion by the meningococcus. Systemic infection with this organism may present two clinical pictures: (1) the familiar cerebrospinal meningitis, in which the central nervous system bears the brunt of the attack, giving the most striking manifestations of the disease, and (2) the so-called meningococcemia, in which the blood stream is affected. In either of these two diseases pain is occasionally noted in many small joints, such as in the fingers or wrists. This pain is usually transient and migratory and is comparable to that in gonococcal arthritis. Soon, however, an acute episode of persistent pain, swelling, and effusion occurs in one of the large joints, such as the knee. Pathologically, the picture is that of an intense acute inflammatory response of the synovium. It is difficult to culture the organism from the joint fluid. Nevertheless, sections of the synovium reveal the organism embedded in it. The synovium is thickened, becomes intensely hyperemic, and is invaded by numerous polymorphonuclear leukocytes. Inasmuch as the synovium, rather than the articular cartilage, bears the burden, there is not the tendency toward ankylosis in this condition that there is in suppurative or gonococcal arthritis.

Treatment consists of aspiration to relieve the intracapsular tension, strapping (used mainly for the knee) to prevent too rapid a reaccumulation of the effusion, splinting of the affected joint not only to rest the tissues, but also to prevent flexion contracture, and administration of the appropriate antibiotic to overcome the systemic infection. The pain and swelling subside very slowly,

Hypertrophic Arthritis

The etiology of hypertrophic arthritis is in dispute. Some believe that the process is due to the wear and tear of a lifetime of use, whereas others believe that the changes are brought about as a result of some generalized metabolic disorder. Whichever view is taken as to the etiology, at least the pathologic and roentgenographic changes can be described and recognized and the clinical picture presented.

Hypertrophic arthritis affects mainly the large joints, especially the hip and knee, and commonly involves the vertebral column. When it does affect the small joints, it has a predilection for the distal interphalangeal joints of the hand. The disease occurs in the older age groups, (in persons over 40 years of age), and it is most commonly seen in the heavy, robust, overweight person. Pathologically, there is first fibrillation of the articular cartilage, with degeneration of the cartilage. Attempts to repair the area of degeneration are made by granulation tissue and by subchondral bone (by laying down sclerotic bone). Therefore, the articular surfaces show irregular patchy areas where degeneration of cartilage has occurred and a concomitant sclerosing process in the underlying bone. At the junction of the joint capsule with the bone, which takes place at the outermost edges of the articular cartilage in many joints, bony spurs form as a result of proliferation. Consequently, the roentgenograms reveal narrowing of the joint space (due to loss of articular cartilage), irregularity of the joint surfaces (due to the patchy manner in which the articular cartilage degenerates), sclerosis or eburnation of the joint surfaces (due to the proliferation of the subchondral bone), and jagged bony spurs projecting into the soft tissue from the joint margins. Clinically, the patient complains of a dull ache which becomes more severe upon use of the affected joint. Cold and damp weather or sudden changes in the weather affect these joints adversely, and patients experience more pain and discomfort during such periods. Minor traumas to a hypertrophic joint frequently cause pain disproportionate to the sustained injury and may severely aggravate already existing pain. Not infrequently one of the bony spurs is broken off, and severe, persistent pain may result.

Examination of the affected joint frequently reveals it to be swollen and to contain an effusion. The range of motion sometimes is diminished by pain, effusion or incongruity of the articular surfaces, but there is little, if any, tendency toward fibrous or bony ankylosis. Crepitus and grating can frequently be palpated as the joint is moved through a range of motion. The distal interphalangeal joints often present nodules, called Heberden's nodes, which are characteristic of hypertrophic arthritis.

The type of treatment depends upon the severity and site of the arthritis and the resultant disability. In general, heat in the form of moist, hot towels, heating pad, hot water bottles, or warm baths affords relief. Rest for the joint, either by using splints or by limiting activities, temporarily at least, aids in ameliorating the symptoms Massage and the local application of a liniment, such as oil of wintergreen or chloroform liniment, also gives relief. Regular doses of aspirin should be prescribed, and the intra-articular instillation of Hydrocortone provides relief for a time.

say, the joint must be in a position of optimum function because this treatment is directed toward producing bony ankylosis in order to heal the tuberculous process. If, after a fair trial of conservative management, the disease continues to progress, radical treatment, consisting of operative fusion of the joint, is indicated. Fusion of a joint can be performed by either the intra-articular or the extra-articular method. Whenever possible, an extra-articular arthrodesis should be performed, since it avoids operation in an infected field. Some joints do not lend themselves to extra-articular fusion, and in such cases operation in a contaminated area is unavoidable. Arthrodesis can be performed in several ways; in general, the diseased articular surfaces are cut away, and the raw,



Fig. 166 —Tuberculosis of the hip. Note narrowing of the joint space and destructive changes both in the femoral head and the ilium

bleeding bone ends are approximated. A graft, if desired, may be used to bridge the joint. Following the operation, a cast is applied, with the bones aligned so as to give optimum function when ankylosis occurs. If an extra-articular arthrodesis is attempted, a bone graft is inserted from one bony prominence to another, and the joint is avoided, for example, in the insertion of a graft from the greater trochanter to the wing of the ilium, the hip joint is not entered. Streptomycin is administered in conjunction with PAS (para-aminosalicylic acid) as an adjunct in the treatment of joint tuberculosis, but the principles of immobilization, arthrodesis, and position of optimum function should not be ignored in favor of chemotherapy. Some advise incision and drainage of a tuberculous process just as for pyogenic suppuration.



Fig. 167.—Subtrochanteric osteotomy of the right hip and Vitallium cup arthroplasty of the left hip (two methods of dealing with hypertrophic changes of the hip)



Fig. 168.—Vitallium cup arthroplasty for a hip Performed on a relatively young patient to afford relief from disabling hypertrophic arthritis.

More specifically in regard to the management of hypertrophic arthritis of the knee, if the measures just described fail, a plaster cylinder applied so that the patient can walk but not bend the knee sometimes relieves symptoms in the joint for as long as nine to twelve months. The cylinder may be kept on for two to four weeks. If the disability is great and the cylinder fails to produce results, surgical procedures, such as the excision of surrounding spurs or a synovectomy, can be carried out. The knee joint, particularly, lends itself well to the injection of intra-articular Hydrocortone.

Malum coxae senilis is a condition in which the hip undergoes changes such as occur in hypertrophic arthritis. In this condition the head of the femur becomes cystic and softened, the weight-bearing surface becomes flattened and irregular, and the head mushrooms down over the neck. A great deal of bony proliferation takes place at the junction of the head with the neck, resulting in masses of irregular bone which severely limit motion. At times the disability is so great and the pain so severe that radical intervention is justified. There are at least three possible operative procedures. In the first, the joint is fused in a position of optimum function. Such a fusion eliminates pain inasmuch as the pain is due to irritation of the synovium by irregular bone impinging upon it during motion. An arthrodesis then is performed by exposing the joint surgically, excising the articular cartilage, and placing a bone graft directly from the femur to the ilium. However, many patients fail to see the wisdom of having a stable, painless, but immovable hip and therefore refuse such a procedure. In the second operative procedure the weight-bearing line and the weight-bearing surface of the hip joint are changed. This is achieved by a subtrochanteric osteotomy. In this operation the shaft of the femur is cut through just below the trochanteric region. The distal portion is brought into abduction so that the femur bends medially at the subtrochanteric region. (Fig. 167.) Both fragments are held by pins (which may protrude through the skin) until bone healing is complete. This operation has the effect of rotating the head of the femur in such a way that the original medial surface becomes the superior weight-bearing surface. A third procedure is a Vitallium cup arthroplasty. (Fig. 168.) The Smith-Petersen anterior (iliofemoral) approach is used to expose the hip joint. The head of the femur is dislocated out of the acetabulum and then rounded off and smoothed with Murphy reamers, and the surrounding proliferations of bone are excised The acetabulum is smoothed, and a Vitallium mold or cup is introduced between the head of the femur and the acetabulum when the head is replaced in its socket The physical therapy following this procedure is essentially the same as that following any arthroplasty of the hip. We believe that the Vitallium cup arthroplasty, when properly done, offers much relief to the patient with malum coxae senilis.

Reconstruction of the hip by a prosthesis has also been proposed. After exposure of the hip anteriorly, the head of the femur is removed and is replaced by the prosthesis (Fig. 119), which is the size and shape of the head. Theoretically, there are objections to the prosthesis which might be borne out at a later date. It is extremely difficult to fashion any prosthesis so that it will be an exact replica of its counterpart in a human being. If, in reconstruction of the

relationship with rheumatic fever, so that a patient with atrophic arthritis gives a history of the same type of arthritis or of rheumatic fever in a parent or sibling more commonly than would be expected by mere chance.

The disease manifests itself in three main forms—acute, subacute, and insidious. These terms apply mainly to the onset. All forms of the disease tend to become more chronic as time goes on. Patients with an acute onset have a better prognosis than those with an insidious onset.

Strangely enough, pregnancy or jaundice occurring during an attack of atrophic arthritis often brings about a remission; pain and swelling disappear and the range of motion in the affected joint improves. However, following delivery, there is likely to be a recurrence of the arthritis which may be a little worse than before.

It cannot be emphasized too strongly that this disease is a general systemic one rather than simply a disease of the joints. The joint symptoms are local and perhaps the most dramatic manifestations of the systemic process. In addition to the joints, it is thought that the bones, muscles, skin, peripheral nerves, and maybe even the heart are affected. The systemic nature of the process is also demonstrated by a fever, which at times is high, but which commonly is low grade, fluctuating between 99 and 100° F. and continuing for months. The sedimentation rate is increased. Excessive and easily provoked fatigue is a complaint. Loss of weight, lack of ambition, and general lethargy are also manifestations of this disease. In the more severe cases there is a tendency toward fibrous and bony ankylosis of the joints.

Prognosis is indeed difficult to determine. About 30 per cent of the patients have one attack only and recover completely, and around 50 per cent have recurrent attacks which are only moderately disabling. However, in 10 to 20 per cent the disease follows a cruel and inexorable course, ending in total disability, with almost every major joint in the body ankylosed, usually in dreadful deformities. The vastness of the problem can be appreciated when one realizes that some authorities feel the disease is as common as heart disease, cancer, and tuberculosis combined.

Certain pathologic changes will now be presented. The periarticular tissue undergoes a proliferation in the granulation tissue (swelling around the joint). The synovium becomes thickened and vascular and is infiltrated with lymphocytes (having the boggy sensation of chronic synovitis to palpation). A pannus of granulation tissue extends from the synovium over the articular cartilage, destroys the articular cartilage in spotty areas, and invades the subchondral bone. On the roentgenograms this is seen as narrowing of the joint space, irregularity of the joint surface, and small, juxta-articular, punched-out areas. The bones entering an affected articulation reveal atrophy which is also visible on the roentgenograms (Fig. 169.) When sufficient articular cartilage is destroyed, raw bone comes in contact with raw bone, and bony ankylosis may result. During the time that a given joint is painful, a flexed position tends to be more comfortable. Therefore, the patient holds the joint in a position of flexion, the capsule loses its elasticity, and a flexion contracture may result. The skin of the hands is likely to be smooth, shiny, thin, tense, and atrophic. The

hip, the prosthesis replacing the head of the femur in the acetabulum does not exactly conform, joint incongruity, with the possibility of attendant hypertrophic changes, results. In addition, the normal stresses and strains of weight-bearing that are placed on the inert material placed into the bone is likely to result in bone absorption. The procedure has been criticized as a destructive one; if it fails for some reason, such as bone absorption, the difficulties then presented are obvious. Intelligent and skillful use of the Vitallium cup, combined with bone grafts and tendon transplantations, by an experienced operator seems to give results as satisfying as those obtained from a prosthesis.

Hypertrophic arthritis commonly affects the lumbar spine, giving rise to an annoying and at times disabling back pain. Sleeping on a firm mattress and a fracture board, application of heat in the form of warm baths, moist, hot towels, and hot water bottles, and the local application of oil of wintergreen at least ameliorate the pain. At times a support is necessary to limit motion in order to obtain relief.

In the cervical spine the foramina for the exit of the segmental nerve trunks are narrower than in the lumbar spine. When these foramina are encroached upon by the process of hypertrophic arthritis (Fig. 140), symptoms of nerve root irritation occur. These symptoms are variable, but the patient complains of pain over the occiput, down along the edge of the trapezius, on top of the shoulder, in the arm, or even over the precordium. The symptoms may closely mimic those of cardiac angina. Relief is commonly obtained by head traction or by the application of a Thomas collar, which limits motion of the cervical spine. At times, diathermy or a cast or brace is used. Vitamin B_{12} appears to be of aid as an adjunct, and salicylates are of course helpful.

Atrophic Arthritis

Atrophic arthritis is also called rheumatoid arthritis, ankylosing arthritis, chronic arthritis, or chronic progressive arthritis. The etiology of the disease is entirely obscure. Some believe that this type of arthritis is related to infections, especially those due to streptococcus or its toxins. Others emphasize the role of emotional factors. More recently, the endocrine system is being investigated for its possible etiologic role. Consequently, it would seem best simply to describe the process pathologically and clinically and to leave clarification of the etiology to the future.

Atrophic arthritis is much more common in women than in men. It attacks those in the younger age groups (between 20 and 30 years of age). By preference, the disease begins in the small joints and later passes to the large joints. The proximal interphalangeal joints of the fingers are particularly prone to be affected, and the fusiform swelling of these joints is characteristic of the disease. There is a tendency for the process to be bilaterally symmetrical. Exacerbations and remissions occur in the natural course of the disease, making evaluation of any therapy difficult. Persons with a tall, thin body build are more commonly affected than are short, stout, robust persons. It is well known that the disease frequently begins immediately following a severe emotional upset, such as a death in the family. There is a hereditary tendency and perhaps a



Fig. 169.—Rheumatoid arthritis showing bone atrophy and narrowing of the joints.



Fig 170 —Arthritic hands Note the enlarged metacarpophalangeal joints and the spindle-shaped fingers due to swelling of the proximal interphalangeal joints The ulnar deviation of the fingers on the right hand is a common deformity. (From Larson, C. B., and Gould, M.: Calderwood's Orthopedic Nursing, 1957, The C V Mosby Co)

muscles reveal collections of lymphocytes which are associated with blood vessels on the periphery of a muscle bundle. Occasionally, these collections of lymphocytes are found within a muscle bundle surrounding degenerating muscle fibers.

The clinical picture is that of a woman 20 to 40 years of age who complains of pain, stiffness, and aching in the proximal interphalangeal joints of the fingers of both hands. The pain may have been present constantly for weeks or months, with only short intervals of freedom from pain. Examination reveals a thin, pale, young woman with shiny skin on the hands and fusiform swelling in the proximal interphalangeal joints. (Fig. 170.) The joints will be tender to palpation and painful to active and passive motion, and the range of motion will be decreased. There will be a tendency for the fingers to be held in flexion. A low-grade fever (temperature of 99 to 100° F.) may be present, and the sedimentation rate will probably be elevated.

If the course of the disease in such a patient is followed for a long time, it will be noted that the pain and swelling in the proximal interphalangeal joints will probably subside, and the patient will be asymptomatic for a long or short period. Then both knees, both shoulders, or both elbows may suddenly become painful and swollen. After weeks or months, these joints may also become asymptomatic for a long or short period. Then both knees, both shoulders, or both elbows (all of them or any combination of them) may suddenly become painful and swollen. The proximal interphalangeal joints of the hands will perhaps again show a recrudescence of the disease. After weeks or months the patient will complain of pain and tenderness in the muscles around the large joints. It is impossible to predict when a remission or an exacerbation will occur. Treatment in atrophic arthritis is divided into the medical and the orthopedic, which is tantamount to saying general and local treatment.

Since this is a systemic disease, the medical treatment is directed toward complete mental and physical rest, much like the treatment for tuberculosis. Foci of infection are sought and cleared up not because of any etiologic importance, but because of their effect on health in general. The patient should avoid overwork, stay out of drafts, and generally guard against upper respiratory infections. The diet should be as nutritious as possible, with a high vitamin content. These measures obviously attempt to improve the patient's general well being and resistance. Aspirin is the best drug to use to lessen the pain. Habit-forming drugs should not be used, since medication for pain in atrophic arthritis has to be continued for a long time.

Until the introduction of ACTH and cortisone, the intramuscular injection of soluble salts of gold had enjoyed the greatest and most sustained popularity, perhaps, of all the exceedingly numerous therapeutic agents which had been tried. The gold salts are injected once a week for several weeks until a course has been given. A course is usually that length of time needed to administer a total of about 1 Gm. of gold. It is reported that about 70 per cent of the patients are much or definitely improved. Remissions during the natural course of the disease make it difficult to judge the effectiveness of gold therapy. The disadvantages of gold therapy are as follows: (1) It is an empirical agent whose mode of action is not thoroughly known; (2) it is a toxic substance and should

then allow complete extension at the knee. A plastic lengthening of the tendons may also be done. If the flexion deformity due to bony ankylosis presents a grave disability, arthroplasty can be carried out. If the motion of the knee is limited by an extremely thickened synovium, a synovectomy to improve motion is indicated. Hence, the objectives of the orthopedist in the management of atrophic arthritis are to prevent deformity (by using splints) and to maintain joint motion (by prescribing intelligent, carefully applied physical therapy). If deformity has occurred, then the application of traction or the performance of some thoroughly considered operative procedure offers much relief.

To avoid confusion, we will briefly contrast atrophic arthritis and hypertrophic arthritis. The greatest incidence of atrophic arthritis occurs between 20 and 40 years of age; hypertrophic arthritis occurs in the older age groups. Atrophic arthritis usually affects slender persons; hypertrophic arthritis affects stout persons. Atrophic arthritis is common in females; hypertrophic arthritis affects either sex about equally. Atrophic arthritis characteristically attacks the proximal interphalangeal joints; hypertrophic arthritis attacks the distal interphalangeal joints. While atrophic arthritis tends toward contractures and bony ankylosis, hypertrophic arthritis does not. Atrophic arthritis is a process of periarticular soft tissue proliferation, with destruction of the bone and joint surfaces; hypertrophic arthritis is a process of proliferation of bony spurs and eburnation of the joint surfaces.

There are certain special forms of atrophic arthritis: Marie-Strümpell arthritis, Still's disease, Felty's syndrome, and intermittent hydrarthrosis.

Marie-Strümpell arthritis begins most commonly in a young man who may have suffered recently from gonococcal prostatitis. The arthritic disease usually first attacks the sacroiliac joints, passing on up the vertebral column from there. In addition, it is possible that certain peripheral joints, such as both hips or both knees, may be involved. The process ends in bony ankylosis of the joints of the posterior arches of the vertebrae and of the sacroiliac joints, producing the so-called "poker spine." Pain in the sacroiliac region is the initial complaint when these joints are involved first. The roentgenograms reveal clouding of the sacroiliac joints at this stage of the disease. Eventually, the pain disappears when bony ankylosis has obliterated the sacroiliac joints. However, the next to be affected are the zygapophyseal joints, which are the joints between the superior and inferior facets which project from off the posterior bony arch of the vertebral column. The pain then progresses from the lumbar region upward as each level is successively involved in the inflammatory process, eventually leading to ankylosis. When ankylosis has taken place, there is no longer any pain. The roentgenograms now reveal obliteration of the sacroiliac joints, ankylosis of many of the lower zygapophyseal joints, and calcification of the long ligaments binding the vertebral bodies together. (Fig 134.) During the painful period (which often lasts two to three years), the spine tends to flex; hence, healing may result in a very marked curved deformity of the entire vertebral column.

The use of ACTH and/or cortisone might alter some of the principles of treatment which heretofore orthopedists have considered necessary in the manage-

be given only by those familiar with its danger; and (3) it does not attack the basic, underlying process responsible for the disease. The toxic reactions of gold include leukopenia, exfoliative dermatitis, ulcerative stomatitis, and renal failure.

Rheumatoid arthritis is now treated frequently with ACTH (the adrenocorticotrophic hormone of the pituitary gland) or with cortisone (a hormone of the adrenal cortex). The results after the use of these agents are remarkable. Within a matter of hours or, at most, a few days, the patient experiences a sense of well being, the pain is largely diminished, the swelling in the joints subsides rapidly, and the joint motion improves. It is hoped that patients in the early stages can be placed in permanent remission by treatment with ACTH. It should be kept in mind that the disease is probably still present and, although it might be quiescent for a while, that recurrences will most likely ensue sooner or later. In patients in whom the disease is of longer duration, prolonged treatment with ACTH or Cortone should be contemplated. Naturally, the limitation of motion due to bony changes in or around the joints will not be altered by these agents. In other words, in the so-called "burned-out" cases with ankylosis improvement should not be anticipated. About 60 to 75 mg. of ACTH is a sufficient daily dose to maintain a patient in comfort and permit his usual activities. If cortisone is used, 100 mg. in divided oral doses, is usually adequate. It is well to reduce the dose gradually over a long period to time, until it can be discontinued. If a recurrence supervenes, the medication is started again. Careful follow-up should be made on patients being treated with ACTH and cortisone to detect shifts in the serum-electrolyte balance (especially in sodium and potassium), signs of water retention, and glycosuria. Occasionally, emotional disturbances arise which are of sufficient magnitude to warrant cessation of treatment. While ACTH and cortisone should not be regarded as *cures* for rheumatoid arthritis, they are the most powerful and successful agents yet discovered in the treatment of the disease.

Care of the joints is the responsibility of the orthopedist, and since treatment depends upon the specific condition of a patient, only general principles can be outlined.

A painful joint tends to flex and become contracted in the flexed position. Such a joint is usually less painful when splinted. Therefore, in the acute phase (pain and swelling of a joint), a splint should be applied, whether the finger or the knee is involved. However, the splint must be removed very frequently to exercise the joint. The exercise must be *gentle* and passive, and the joint should be moved through the greatest range of motion possible without initiating pain. Since heat, in the form of contrast baths, warm paraffin, diathermy, or heat lamps, reduces the pain, it should be applied intermittently, provided the process in the joint is not too acute. If the flexion deformity is not due to bony ankylosis, skeletal traction will frequently correct the condition. The knees are often the site of flexion contracture and if, after trying skeletal traction, extension of the knee is not obtained, it is possible to perform a posterior capsulotomy. In this procedure the posterior capsule of the knee joint is divided or stripped from its attachment to the bone so that the contracted soft tissues

Uric acid in the blood is elevated. The acute form of the disease gradually becomes chronic, but deformities are not common.

Treatment is medical and includes a high protein but low purine diet, a high fluid intake, and the administration of colchicine. Cortisone is also successfully used. A discussion of gout is included because it must be considered the basis for joint pain in certain instances.

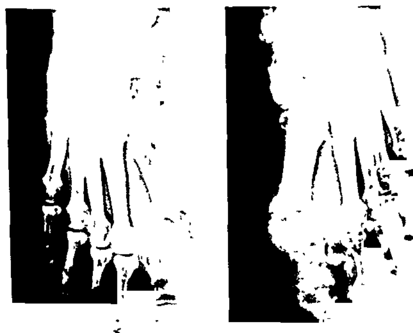


Fig 171 —Gout Note the predilection for involvement of the first metatarsophalangeal joint.

Charcot's Joint or Neuropathic Joint

When a patient is suffering from a disease of the central nervous system, such as tabes dorsalis, syringomyelia, or transverse myelitis, an associated affection of a large joint called Charcot's joint or neuropathic joint may arise.



Fig 172 —Charcot or neuropathic joint Note general disorganization of the joint and lateral dislocation of the tibia or femur The clinical swelling and instability could be deduced from such films.

ment of the disease. If, however, ACTH and cortisone are contraindicated for some reason, the older principles of treatment will have to be employed. Consequently, the treatment for such a patient is directed toward gaining ankylosis in a good position of the spine. This means that the patient should sleep on a fracture board and wear a Taylor back brace when up and around. Postural exercises are helpful. If, in spite of such measures, flexion of the spine seems uncontrollable, the patient should be hospitalized and placed on a Bradford frame in a position of hyperextension of the spine.

When the process has ankylosed the spine, the hip joints are sometimes affected. If the process is sufficiently acute, the hips should be immobilized in a position of optimum function so that ankylosis in a very bad position of flexion and adduction will not occur. If the patient seeks correction of a disabling deformity once ankylosis has occurred, several operative procedures are possible. If both hips are ankylosed, the disability is so grave as to demand arthroplasty. This can be accomplished by using a Smith-Petersen anterior approach to the hip joint, cutting through the ankylosis at the old joint line, and inserting a Vitallium cup. Arthroplasty with a prosthesis is also a possible means of therapy. (The advantages of a prosthesis and of a Vitallium cup were discussed under Hypertrophic Arthritis.) Should a cup arthroplasty be inadvisable, a corrective osteotomy may be performed on the femoral shaft to obtain a position of the thigh which will ensure proper hygienic care for the patient. Ankylosis of the thighs in adduction and flexion interfers with both urination and defecation. To correct a spine which is ankylosed in flexion, Smith-Petersen has devised an osteotomy of the spine. In this procedure a region of a few of the ankylosed zygapophyseal articulations is osteotomized; the spine is then brought into correction and fused.

Still's disease is a generalized atrophic arthritis in a malignant form which attacks children

Felty's syndrome is atrophic arthritis with leukopenia and splenomegaly.

Intermittent hydrarthrosis is an affection of the knees and is usually bilateral. Suddenly and without apparent cause, both knees become tense, swollen, painful, and stiff. A large effusion collects in each knee joint. After several days the effusion is absorbed, only to reappear at a later date. The etiology is not clear. Some believe that intermittent hydrarthrosis is allergic in nature. However, it is becoming increasingly apparent that the affection is really a form of atrophic arthritis.

Gouty Arthritis

Gout is perhaps due to a disturbance in the purine metabolism. The disease affects persons in the middle-aged group and is characterized by recurrent acute attacks of pain, swelling, and inflammation in the joints. The metatarsophalangeal joint of the great toe is especially likely to be affected, but the large joints also become painful. Attacks often begin in the night and subside by morning. Males are more prone to the disease Deposits of urates are found in the periarticular structures and, characteristically, as tophi in the external ear. Tophi are pathognomonic of gout. The roentgenograms reveal rather large punched-out areas of destruction of the bone in the juxta-articular regions. (Fig. 171.)

veloping deformities. These deformities are anterolateral bowing of the tibia and femur, kyphosis, and an increase in the size of the skull.

Reticuloendotheliosis

A number of diseases which produce destruction of the bone have been described by various names. These diseases may perhaps be variants of a single underlying pathologic process. Snapper presented the following theme regarding the relationship of the several conditions (Hand-Schüller-Christian disease, Albright's disease (osteitis fibrosa disseminata), Lichtenstein's disease (polyostotic fibrous dysplasia), and eosinophilic granuloma, single or multiple): *Hand-Schüller-Christian* disease is characterized by defects in the skull, infantilism, exophthalmos, and diabetes insipidus. Pathologically, the lesion, including the defects in the skull, is composed of collections of reticuloendothelial cells which are swollen by the fat they contain (foam cells). Hence, essentially it is a granulomatous lesion. The fat is probably cholesterol. There are cases on record in which the lesions were pathologically the same as those found in Hand-Schüller-Christian disease, except that the destruction was found in bones other than the skull, and the infantilism, exophthalmos, and diabetes insipidus were absent. Thus, Hand-Schüller-Christian disease can be considered a type of lipoid granuloma in which the fortuitous involvement of the brain and skull is responsible for the remainder of the clinical picture, including the exophthalmos, diabetes insipidus, and infantilism.

Albright's disease (osteitis fibrosa disseminata) reveals bone destruction, predominantly unilateral, associated with precocious puberty in *girls* and with pigmented skin lesions. Pathologically, this disease shows simple cystic lesions of the bone, with fibrosis. These lesions may be interpreted as having been originally composed of a lipoid ganuloma and are an end result of a previous lesion.

Lichtenstein's disease (polyostotic fibrous dysplasia) also shows multiple areas of bone destruction. It has been suggested that the disease represents a failure of the mesenchyme to produce perfect bone. However, there is some evidence that the lesions in this disease also are simply previous lesions which originally were lipoid granulomas.

Eosinophilic granuloma occurs not only as a single lesion, but also as multiple lesions in numerous bones. Pathologically, the area of destruction in the bone is composed of eosinophils and reticuloendothelial cells containing lipoid (foam cells). Furthermore, there is evidence that in at least one patient with eosinophilic granuloma the condition has developed into a full-blown case of Hand-Schuller-Christian disease.

Therefore, many are coming to believe that Hand-Schüller-Christian disease, Albright's disease (ostitis fibrosa disseminata), Lichtenstein's disease (polyostotic fibrous dysplasia), and eosinophilic granuloma (single or multiple) are all fundamentally the same disease but with different manifestations. If they are the same disease, it seems that the fundamental disturbance is the formation of a granuloma, consisting of reticuloendothelial cells in which cholesterol esters are deposited; hence the name reticuloendotheliosis. The granu-

Hyperparathyroidism

In hyperparathyroidism, an adenoma of the parathyroid gland often develops. Due to the production of excess parathormone, the calcium and phosphorus metabolisms are profoundly disturbed. An increased serum calcium and a decreased serum phosphorous results. The serum calcium is increased at the expense of the calcium stored in the skeleton. The process of washing the calcium out of the bones is called halisteresis. Pathologically, the architectural structure of the bones is altered. Many cystic cavities appear, the bone trabeculae become thinned, and the marrow becomes fibrous instead of cellular. An increase in the number of osteoclasts is observed, and even giant cell tumors appear. Pathologic fracture is common. The alkaline phosphatase may be increased or normal, and urinary calculi often form. Diagnosis is based upon the roentgenograms, which reveal a diffuse loss of calcium from the skeleton, involving almost every bone, the presence of a giant cell tumor, and the characteristic chemical syndrome of increased calcium and decreased phosphorus in the serum. After the parathyroid ademona is removed, improvement in the calcification of the bones occurs. The serum calcium and serum phosphorus return to normal.

Paget's Disease (Osteitis Deformans)

Paget's disease is of unknown etiology. In this disease, which characteristically affects only a few bones (instead of the entire skeleton at one time), a great deal of sclerotic bone is laid down, alternating with a rarefying process. Therefore, in some areas the affected bone appears to be osteoporotic, while in other areas it is much denser than normal. The entire size of the bone increases. Consequently, diagnosis is made from the roentgenograms on the basis of the following characteristics: (1) increase in the over-all size of the bone, (2) coarser, larger, and denser than normal trabeculae, (3) areas of rarefaction interspersed upon a background of a general increase in the amount of calcification and (4) involvement of only one or a few bones affected instead of the entire skeleton. Favorite sites of the disease are the skull, pelvis, vertebrae, and shafts of the tibia and femur

Pathologic fracture is not uncommon. Such a fracture may call the underlying Paget's disease to the attention of the physician. Otherwise, the patient may complain of an increase in the size of his head or bowing of his legs, which may gradually develop as a result of Paget's disease. Microscopic examination reveals the development of a mosaic pattern in the bone trabeculae (instead of concentric or regular lamellae). The marrow is no longer cellular but is replaced by a fibrous tissue. There is a tendency for osteogenic sarcoma to develop in areas of Paget's disease. Due to the fact that a great deal of new bone is being formed, the alkaline phosphatase is increased. The serum calcium and serum phosphorus are normal.

It is noteworthy that while in some areas the density of the bone appears to be increased, the entire bone weighs less than normal. The quality is therefore poor, and this fact explains the pathologic fractures and insidiously de-

Chapter Fourteen

Tumors Involving Bone

There are few fields which present so many difficulties in diagnosis, both clinical and pathologic, as tumors which involve bone. Many of the symptoms are the same, regardless of the specific nature of the tumor. Local swelling which becomes increasingly greater and, later, the development of pain are common complaints, whether the tumor is benign or malignant. Clinically, it may be difficult to distinguish between infection in bone and tumor of bone. At least one tumor (Ewing's sarcoma) may closely mimic acute hematogenous osteomyelitis. Conversely, in certain stages, osteomyelitis and syphilis of the bone may be mistaken for neoplasms. To arrive at a diagnosis, several procedures should be carried out. Needless to say, a very careful history should be taken and a complete physical examination given. Roentgenograms of the lesion and of the chest, especially, should be obtained. The following studies on the blood are of great importance: serum alkaline phosphatase, total serum proteins, with determination of the amount of albumin and globulin, serum calcium and serum phosphorus, and, perhaps the most important of all, a test for syphilis, such as the Wassermann, Kahn, or Kline. The urine should be examined repeatedly for Bence Jones protein. Perhaps as many as seven urinalyses should be carried out in searching for Bence Jones bodies. It is impossible to overemphasize the importance of obtaining a biopsy of the lesion and of submitting it to a qualified pathologist.

The practitioner will find it of particular value to know the specific sites of predilection of the tumors described below. Note should be made of whether the site is in the long or flat bones, and, if it is in the long bones, the exact location. The tumor may arise in the diaphysis (either centrally or exteriorly), in the metaphysis (either centrally or exteriorly in the region of the periosteum), or in the epiphysis (condylar portion) of the long bones. Furthermore, the practitioner should determine whether the tumor is osteosclerotic or osteolytic.

Tumors will be discussed in the following order (in general, the terminology as used by Geschickter and Copeland has been followed):

loma destroys the bone from within outward and may go on to heal, leaving simply a cavity with a fibrous tissue reaction. The granuloma may occur in different anatomic sites, thus giving rise to various clinical pictures, one of which (Hand-Schüller-Christian disease) is dramatic because it involves the brain. The serum calcium, serum phosphorus, and serum cholesterol are normal in all of these diseases. Treatment of a granulomatous lesion, if it is accessible surgically, consists of curetting the lesion and packing the cavity with bone chips.

Gaucher's Disease

Gaucher's disease is characterized by progressive splenomegaly due to the presence of numerous phagocytes containing a lipid kerasin. Such phagocytic cells are present also in the liver and bone marrow. Therefore, destructive lesions of the bone are present. The distal femur is especially prone to exhibit the lesion, which is an expansion of the distal shaft and metaphysis due to a rarefying lesion that destroys the bone from within outward. The disease is rare.

Osteopoikilosis

Osteopoikilosis is a rare familial disease. It is characterized by small, usually rounded areas of sclerotic bone which are, for the most part, found in the epiphysis. Sometimes the metaphysis is involved. The vertebrae are not often affected, and the skull almost never is involved. Synonyms for the disease include osteosclerosis fragilis generalisata, osteitis condensans generalisata, spotted bones, and osteopathia condensans disseminata.

Osteopetrosis (Marble Bones, Albers-Schönberg Disease)

In osteopetrosis, the entire skeleton is affected by a sclerosing process. The bones become thick, heavy, and dense, due perhaps to endosteal proliferation of the bone. There is a decided uniformity in the density of the bones. Due to the narrowing of the optic formanina in the skull, blindness usually results. The roentgenographic diagnosis is based upon finding a uniform increase in the density of the bone throughout the skeleton and a clublike thickening of the posterior clinoid processes of the sella turcica. Clinically, in addition to blindness, there may be hydrocephalus, anemia (with extramedullary hematopoiesis due to the obliteration of the marrow by the sclerotic process), and pathologic fracture. The blood chemistry is normal.

Melorheostosis Leri

Melorheostosis (so named because it resembles flowing candle wax on the roentgenograms) is a sclerotic process affecting a single long bone or the long bones of a single extremity. It apparently is due to endosteal proliferation of new bone starting in the metaphysis and flowing in an irregular manner throughout the medullary cavity of the diaphysis. Thus, on the roentgenograms the change appears to be inside the bone. The external contour of the bone is normal.

Chapter Fourteen

Tumors Involving Bone

There are few fields which present so many difficulties in diagnosis, both clinical and pathologic, as tumors which involve bone Many of the symptoms are the same, regardless of the specific nature of the tumor. Local swelling which becomes increasingly greater and, later, the development of pain are common complaints, whether the tumor is benign or malignant. Clinically, it may be difficult to distinguish between infection in bone and tumor of bone. At least one tumor (Ewing's sarcoma) may closely mimic acute hematogenous osteomyelitis. Conversely, in certain stages, osteomyelitis and syphilis of the bone may be mistaken for neoplasms. To arrive at a diagnosis, several procedures should be carried out. Needless to say, a very careful history should be taken and a complete physical examination given. Roentgenograms of the lesion and of the chest, especially, should be obtained. The following studies on the blood are of great importance: serum alkaline phosphatase, total serum proteins, with determination of the amount of albumin and globulin, serum calcium and serum phosphorus, and, perhaps the most important of all, a test for syphilis, such as the Wassermann, Kahn, or Kline. The urine should be examined repeatedly for Bence Jones protein. Perhaps as many as seven urinalyses should be carried out in searching for Bence Jones bodies. It is impossible to overemphasize the importance of obtaining a biopsy of the lesion and of submitting it to a qualified pathologist.

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Tumors will be discussed in the following order (in general, the terminology as used by Geschickter and Copeland has been followed):

Benign Tumors

1. Osteochondroma (single exostosis)
2. Multiple exostoses (hereditary, deforming chondrodysplasia, metaphyseal aclasis)
3. Chondroma (single)
4. Multiple enchondromas
5. Ollier's disease
6. Giant cell tumor
7. Osteoid osteoma

Malignant Tumors

1. Osteoblastic osteogenic sarcoma
2. Osteolytic sarcoma
   (a) Osteolytic osteogenic sarcoma
   (b) Chondroblastic sarcoma
3. Chondromyxosarcoma
4. Ewing's endothelial myeloma
5. Multiple myeloma
6. Metastatic carcinoma

BENIGN TUMORS

Osteochondroma (Single Exostosis)

Single exostosis occurs in persons between 10 and 25 years of age. The site of predilection is near the ends of the long bones where the large, powerful tendons insert. Therefore, the tumor develops in the region of the metaphysis on the exterior of the bone. The exostosis is an outgrowth of the bone which assumes several shapes but which roughly resembles a spur. It is composed of a base and body of bone and is surmounted by a cartilaginous cap. The patient complains of painless swelling. At times the overlying soft tissue becomes irritated and causes pain and local tenderness. It is possible for this tumor to change to a malignant chondromyxosarcoma. Treatment of a single exostosis consists of excision.

Multiple Exostoses

The condition of multiple exostoses is also known as hereditary, deforming chondrodysplasia or metaphyseal aclasis. It is both congenital and familial and is therefore discovered early in life. Fundamentally, there is probably a disturbance in the normal growth in the metaphyses of the long bones. Hence the long bones are distorted. Normally the diaphysis expands gently to form the flaring metaphysis. In metaphyseal aclasis, however, the process of tubulation is disturbed so that there is an abrupt (rather than gradual) expansion into a widened metaphysis. The metaphysis occupies a greater length of the shaft than it should. Associated with the widened and lengthened metaphysis are numerous spurlike overgrowths of bone (exostoses) which project into the surrounding soft tissue. Not only one but several of the long bones are thus affected. *(Fig. 173.) Treatment is directed toward correcting any deformity* which may result from disturbed epiphyseal (longitudinal) growth.



Fig. 173.—Multiple cartilaginous exostoses. These exostoses are capped by cartilage which tends to mature when the normal epiphyses close. These tumors are familial and benign but can produce symptoms if mechanically injured. Rarely after incomplete surgical removal or with repeated trauma do they become malignant.

Chondroma (Enchondroma)

Characteristically chondroma occurs in persons between 20 and 30 years of age. The short bones of the hands and the flat bones of the ribs and sternum are the sites commonly involved. The tumor is composed of cartilage and is situated within the metaphysis of the bone rather than on the exterior as were the exostoses just discussed. There may be no symptoms whatsoever, and the chondroma may be discovered upon a roentgenographic examination for some other purpose. On the roentgenograms the tumor appears as a moderately large, fairly well-circumscribed area of rarefaction in the interior of the metaphysis of a short bone of the hand. Curettage is the treatment of choice if symptoms are present.

Multiple Enchondromas

Longitudinal growth of bone takes place by endochondral ossification at the epiphyseal line. It is conceivable that the ossification process might fail to convert *all* of the epiphyseal cartilage into bone. If this occurs, then it is apparent that small islands of cartilage or cartilaginous rests would remain in the metaphyses of tubular bones particularly. Such a process may be the fundamental etiologic factor in the development of multiple enchondroma. The roentgenograms reveal numerous rounded defects in the metaphyseal regions in many places throughout the skeleton. (Fig. 174.) Thus, the phalanges, metacarpals, distal radius, distal femur, and proximal tibia are sites of predi-

lection. Biopsy has proved that the rounded defects seen on the x-ray pictures are composed of cartilage. The lesion is situated inside the metaphysis. Multiple enchondromas may be closely related to Ollier's disease.



Fig 174.—Chondromas (multiple enchondromas) which occur in the second to third decades of life They are commonly present in the phalanges of the fingers and toes.

Ollier's Disease*

In Ollier's disease many extremities may be affected, but usually one bone of one extremity or one entire extremity alone is affected. The disease is perhaps due to a disturbance of normal endochondral ossification. Therefore, the longitudinal growth of bone is so severely interfered with that a very short, deformed extremity results. On the roentgenogram the affected bone reveals areas of rarefaction (enchondromas), a marked shortening, and bulbous deformity, much as if growth had taken place transversely instead of longitudinally.

Giant Cell Tumor

Giant cell tumors occur in persons between the ages of 20 and 30 years. The sites of predilection are within the condyles of the distal femur and within the proximal condyles of the tibia. (Fig 175.) The tumor usually involves only *one* of the condyles so that it is eccentrically located in relation to the midline of the shaft of the involved bone Compare this site with that of an exostosis (exterior of the metaphysis) and enchondroma (interior, central area of the metaphysis). The tumor expands the bone from within outward so that only a very thin layer of cortex overlies the area of destruction. In many instances this thin cortical layer is perforated Pathologic fractures are common. On the roentgenograms the giant cell tumor appears as a loculated area of bone destruction, confined at first to one or another condyle of the distal femur or proximal tibia. The condyle seems to be expanded by the lesion. Grossly, the cavity in the bone is filled by a grumous, friable, dirty-gray or yellowish-

*There is doubt that this disease should be classified with tumors.

white tissue. Microscopically, the tumor is very cellular and is composed of a stroma of small, round cells in which numerous multinuclear giant cells are embedded. Clinically, the patient may complain of aching pains following a minor trauma, or, following a more or less severe trauma, he may present with a pathologic fracture. The treatment of choice consists of thoroughly curetting the lesion and packing the cavity with bone chips. There seems to be some question as to whether the true giant cell tumor ever becomes malignant. Some prefer to treat the tumors with x-ray instead of curettage.



Fig. 175 —Giant cell tumor (osteoblastoma). It is usually benign but difficult to differentiate from certain malignant osteogenic sarcomas even after biopsy. Characteristically, these tumors expand the shaft, show little bone reaction, involve the epiphyses of the long bones, and seldom break into a joint cavity

Osteoid Osteoma

Osteoid osteoma may not be a true neoplasm. Nevertheless, it is conveniently described here.

The site of predilection is on one side of the shaft of a long bone. The tumor develops directly within the cortex of the diaphysis or just beneath the periosteum of the diaphysis. The middle segment of the shaft is a common location. Thus, the tumor is eccentric and bulges out on one side of the shaft (compare with the sites of the previously described tumors). The patient complains of pain, and yet the tumor is frequently so well covered by muscle that no object is palpable. The roentgenograms reveal a semicircular bulge of bone on one side of the shaft of the affected extremity (Fig. 176.) In the center of this bone protuberance is a clear area known as the nidus. Microscopically, the tumor consists of

sheets of bone surrounding the nidus. The latter is composed of osteoid tissue (that is, tissue with the structure of immature bone and without calcification of the matrix). Thus is explained the roentgenographic picture of proliferation of bone with a central nidus of rarefaction. Treatment consists of removal of the tumor.



Fig 176.—Osteoid osteoma. Usual x-ray appearance of a central nidus with surrounding sclerosis of the bone. Benign and most often involves the tibia or femur in the age group from 10 to 30 years.

MALIGNANT TUMORS

Osteoblastic Osteogenic Sarcoma

Osteoblastic osteogenic sarcoma occurs in the age group between 15 and 35 years. The lower femur and the upper tibia are particularly prone to attack by the disease. The site of predilection is in the metaphysis, with the lesion extending outward into the surrounding soft tissue. As the name of the tumor suggests, it arises from elements which normally form bone, and the tumor itself forms bone of an abortive nature as it grows. As the tumor invades both the host bone and the surrounding soft structures, it produces a mass of sclerotic bone arranged in planes perpendicular to the host bone. This gives rise to the "sun ray" appearance on the roentgenograms. Microscopically, the tumor contains numerous osteoblasts and some osteoid tissue. Amputation is the treatment of choice Irradiation by x-ray is of little use, since the tumor is highly differentiated and consequently fairly radioresistant. It is said that approximately 25 per cent of the amputations have resulted in five-year cures.

Osteolytic Sarcomas

As suggested by the name osteolytic sarcomas, both osteolytic osteogenic sarcoma and chondroblastic sarcoma are characterized by a *predominance of*

bone destruction. The one tumor arises from tissue which normally forms bone, and the other arises from tissue which normally forms cartilage. Both produce lytic lesions of the bone and therefore are grouped together in this discussion.

Osteolytic Osteogenic Sarcoma.—This tumor arises in the marrow. The roentgenograms reveal an area of bone destruction at the ends of the long bones which begins centrally and develops centrifugally. (Fig. 177.) Microscopically, the tumor is composed of large spindle-shaped cells and a small number of osteoblasts. The prognosis is very poor. Amputation is the treatment of choice.



Fig 177 —Osteogenic sarcoma Malignant, preponderantly osteolytic, and associated with a good deal of new bone formation It frequently breaks through the cortex to produce a soft tissue mass At times the tumor is osteogenic, in which case the x-ray picture shows marked increased density

Chondroblastic Sarcoma.—This is a rare lytic tumor that arises during adolescence. Development of the new growth takes place at the epiphyseal line of the distal femur or proximal tibia. The roentgenograms show a central area of destruction of bone which enlarges from within outward. Microscopically, the tumor is composed of malignant chondroblasts and small amounts of calcifying cartilage. Note that *osteoblasts* are present in osteolytic osteogenic sarcoma and that *chondroblasts* are present in chondroblastic sarcoma.

Chondromyxosarcoma

Chondromyxosarcoma, which may arise in an independent lesion or in an exostosis, occurs in persons between 15 and 20 years of age. The site of predilection is at the periosteum of the metaphysis of the distal femur and proximal tibia. The tumor is situated largely in the soft tissue, but in the late stage it invades and destroys bone. The roentgenograms reveal an irregular shadow whose density is slightly greater than that of muscle. In the late stages the subadjacent bone becomes eroded. Microscopically, a myxomatous stroma containing fetal and adult cartilage cells is seen. There may be a small amount of bone formation. The growth of the tumor is extremely rapid, the degree of malignancy is high, and the prognosis is grave. Amputation and irradiation with radium constitute the treatment of choice.



Fig 178.—Ewings' sarcoma, malignant It can resemble osteomyelitis clinically and on the x-ray pictures, and most often is near the midshaft of long bones. New bone formation in onion layers is characteristic.

Ewing's Endothelial Myeloma

Ewing's endothelial myeloma occurs from birth to approximately 20 years of age. The patient sometimes has a generalized systemic reaction consisting



Fig 179A.—Multiple myeloma It is almost always osteolytic, with no surrounding bone reaction. In typical cases with skull involvement the diagnosis is more clear-cut.



Fig 179B.—Multiple myeloma, malignant Its common location is in the spine, with complete destruction of the verbral body leaving the disc tissues uninvolved.

of an elevated temperature and leukocytosis. The tibia and femur are frequently involved. The tumor arises centrally in the shaft, in contradistinction to the other types of malignant tumors discussed. (Fig. 178.) It never affects the epiphysis *primarily.* New bone, both endosteal and periosteal, is laid down in the involved shaft because the tumor stimulates new bone formation. Hence, several successive layers of new bone are applied in the shaft, producing an "onion peel" appearance. The entire shaft of the bone is expanded and increased in size. Later on, destruction of the medullary cavity and the cortex occurs. Microscopically, the tumor is composed of small, rounded cells resembling lymphocytes.

The prognosis is poor. Treatment consists of amputation and x-ray irradiation.



Fig. 180.—Carcinoma of the breast, metastatic to the bone, solitary metastases usually to the vertebrae or femur. The more common type of lesion is osteolytic, but occasional cases show bone formation and resemble metastatic carcinoma of the prostate.

Multiple Myeloma

Almost all of the tumors discussed thus far occur in children or young adults. Multiple myeloma, on the other hand, has its greatest incidence in persons around 50 years of age. The tumors develop simultaneously in many foci where red marrow is present. Hence, the sites of predilection are the spine, ribs, and skull. The patient complains of migratory pains which occur in a bizarre pattern. The pain is often sharp, shooting, and radicular. Bence Jones protein is present in the urine in 50 to 75 per cent of the patients. An increase in the total plasma protein, with a reversed albumin-globulin ratio, is expected. The

roentgenograms reveal numerous round, punched-out areas in the vertebrae, ribs, and skull. (Fig. 179*A* and 179*B*.) Microscopically, the tumor is richly cellular, composed of cells which look like plasma cells. The disease is always fatal.

Metastatic Carcinoma

Metastatic carcinoma can produce both lytic lesions and osteoblastic lesions of bone. (Fig. 180.) Carcinoma of the breast and hypernephroma are the two most common carcinomas which produce a lytic type of metastatic lesion. The ovary, the lungs, and the thyroid gland must also be considered as primary sites responsible for a lytic lesion in bone. Carcinoma of the prostate usually produces an osteoblastic type of metastasis. Lytic lesions from carcinoma of the prostate are possible, just as osteosclerotic lesions are possible from metastatic mammary cancer.

SUMMARY OF SITES OF TUMORS

It may be helpful to summarize the sites of predilection for the various tumors described in this chapter.

Site	Tumor
Flat bones of vertebrae, skull, and ribs	Multiple myeloma
Flat bones of ribs and sternum	Chondroma
Shaft of long bones (interior or central)	Ewing's sarcoma
Shaft of long bones (exterior)	Osteoid osteoma
Metaphysis of small, tubular bones, such as phalanges and metacarpals (central or interior)	Enchondroma
Metaphysis of long bones (central or interior)	Multiple enchondroma
	Osteoblastic osteogenic sarcoma
	Osteolytic osteogenic sarcoma
	Chondroblastic sarcoma
Metaphysis of long bones (exterior)	Exostosis (single and multiple)
	Chondromyxosarcoma (primary and secondary)
Epiphysis or condylar portion	Giant cell tumor

A lead to the diagnosis of the type of tumor may be obtained by observing where the tumor seems to be taking its origin.

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